IJCSIS Vol. 12 No. 11, November 2014
ISSN 1947-5500

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Index Terms – Commitments, Web Service, Consistency, Social Networks, Social Web Service.

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Abstract — With the widespread use of harmonic generating devices, the control of harmonic currents to maintain a high level of power quality is becoming increasingly important. An effective way for harmonic suppression is the harmonic compensation by using active power filter. This paper presents a comprehensive survey of active power filter (APF) control strategies put forward recently. Many control techniques have been designed, developed, and realized for active filters in recent years. This paper presents different types of control techniques like PQ theory, Synchronous reference frame methods for real time generation of compensating current for harmonic mitigation and reactive power compensation. All the techniques are analyzed mathematically and simulation results are obtained which are being compared in terms of its compensation performance with different parameters under steady state condition. The techniques analyzed are the PQ theory, Synchronous Reference Frame Theory (SRF), SRF theory without synchronizing circuit like phase lock loop (PLL) also called instantaneous current component theory and finally modified SRF theory. Simulation results are obtained under sinusoidal balanced voltage source balanced load condition. The comparison and effectiveness of all the methods is based on the theoretical analysis and simulation results obtained with MATLAB employing a three phase three wire shunt active filter test system. Finally shunt active power filter is applied to BLDC drive application. THD plots with and without APF are presented.

Keywords-component; Synchronous Reference Frame, instantaneous current component theory, Modified SRF, Active Filter, Harmonics. BLDC Drive

C. Ganesh, Dr. M. Padma Lalitha, P. Divya
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Dept. of EEE, A.I.T.S-Razampeta, A.P, India.

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Keywords-distributed generating (DG), fuzzy logic controller (FLC), islanding mode, 3-phase power converter, phase-locked loop (PLL), proportional-integral controller (PI),and voltage source inverter (VSI).

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Nookareddy Thulasi, PG Student, Department of EEE, Annamacharya Institute of Technology & Sciences, Rajampet, AP, India,

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Dept. of EEE, AITS, Rajampet, India

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S. Mahaboob Basha, S. Sarada, P. Bhagya Lakshmi
Dept. of EEE, AITS, Rajampet, India.

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Index Terms— Doubly fed induction generator (DFIG), Battery energy storage system (BESS), grid power leveling, vector control, wind energy conversion system (WECS).

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Naganathan E.R, Professor& Head, Department of CSE, Hindustan University, Chennai. India

Abstract - This paper presents implementation of Fuzzy logic in web personalization. Web personalization is a process of getting access to a requested page during the browsing of web pages. In order to achieve quick access to the requested webpage, log details of user is used as the a priori data. Conventional statistical methods are available to access the requested webpage. However, due to the vast number of users accessing a particular website, intelligent techniques have to be developed for handling huge amount data. In this paper, Fuzzy logic approach has been used for web personalization.

Keywords: Web server log, Web usage mining, Data mining, e-learning, Fuzzy logic

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Abstract - The paper demonstrates the basic module, steady state operation, mathematical analysis, and current injection modeling of the DPFC for two areas. The purpose of the work reported in this paper is to design an oscillation damping controller for DPFC to damp low frequency electromechanical oscillations. The optimal design problem is formulated as an optimization problem, and particle swarm optimization (PSO) is employed to search for the damping controller parameters. Results demonstrate that DPFC with the proposed model can more effectively improve the dynamic stability and enhance the transient stability of power system compared to the genetic algorithm based damping controllers. The r and λ are relative magnitude and phase angle of DPFC controller. Moreover, the results show that the λ based controller is superior to the r based controller.

Keywords: DFACTS, DPFC, UPFC, Power Flow Controller, current injection model.

Consistency of Commitments in Social Web Services

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Abstract **- Web Service is one of the most important information sharing technologies on the web and one of the example of service oriented processing. To guarantee accurate execution of web services operations, they must be accountable with regulations of the social networks in which they sign up. This operations implement using controls called "Commitment". This paper studies commitments , then has an overview on existing researches, web service execution method using commitments and information sharing methods between web services based on commitments and social networks. A key challenge in this technique is consistency ensuring in execution time. The aim of this study is presenting an algorithm for consistency ensuring between commitments. An application designed for proving correctness of algorithm.**

Index Terms – Commitments, Web Service, Consistency, Social Networks, Social Web Service.

I. INTRODUCTION

Web Service is one of the important information for sharing technology on the web and one of the examples of service oriented processing. According to the W3C, a Web service "*is a software application identified by a URI, whose interfaces and binding are capable of being defined, described, and discovered by XML artifacts and supports direct interactions with other software applications using XML based messages via Internet-based applications*".

In recent years, there has been an increasing interest in social networks and Web Services. Regarding the growth of social networks and a tendency for joining those, web services can be looked from a new perspective named social computing. A prime example for those processes is application based on WEB2 like social networks and blogs. Social computing can analyze how to composite and share web services, keep information security and have fault tolerance [1].

On the other hand, service-oriented computing is the development of applications based on the theory that says: "*I offer services that somebody else may need*" and "*I require services that somebody else may offer*" [2].

With merging service oriented computing and social computing, social web services can be produced that are more complicated from regular web services. To guarantee accurate execution of social web services operations, they must be accountable and adjustable with regulations of the social networks in which they sign up [1]. These operations implement using controls called "Commitment". In other words, transactions between web services components and social networks lead to creation, management and using of commitments [3].

II. BACKGROUND

This section provides an overview of social web services and regular web services consisted of commitments.

A. Overview on Social Web Services.

The synergy between social computing and service oriented computing has eventuated into social web services. Existing research focuses on adopting web services to social networks.

Maaradji proposed a social constructor named "SoCo" to suggest and help users for next their operations (like selecting specific a web service). So users may like to perform an operation that their friends have done in social networks [4].

Maamar purposed an approach for weaving social networks operation using web services. The result of his researches lead to creating social web services [5].

In the other research, Maamar et al. categorized social networks to three group including [6]:

- Collaboration social networks. "By emerging their respective functionalities, social Web services have the capacity to work together and response to complex user requests. In fact, a social Web service manages its own network of collaborators".
- Substitution social networks. Although social Web services compete against each other, they can still help each other when they fail as long as they offer similar functionalities.
- Competition social networks. Social Web services compete against each other when they offer similar functionalities. Their non-functional properties differentiate them when users' non-functional requirements must be satisfied Overview on Commitments.

B. Overview on commitments

First time, Fornara and Colombetti defined a general Formula for commitments. They used commitments for speech evaluation [7].

Bentahar et al. proposed a new persuasion dialogue game for agent communication. They modeled dialogue game by a

framework based on social commitments and arguments, Called Commitment and Argument Network (CAN). This framework allows to model communication dynamics in levels of activities that agents apply to commitments and in levels of argumentation relations. This dialogue game is specified by indicating its entry conditions, its dynamics and its exit conditions. They proposed a set of algorithms for the implementation of the persuasion protocol and discuss their termination, complexity and correctness [8].

Singh et al. are the first of few who advocated for examining Service-Oriented Architecture (SOA) principles from a commitment perspective. As regarding Existing service-oriented architectures are formulated in terms of low level abstractions far removed from business services. In CSOA[1], the components are business services and the connectors are patterns, modeled as commitments, which support key elements of service engagements [2].

El-Menshawy et al. showed that current approaches fail to capture the meaning of interactions that arise in real-life business scenarios and proofed commitments increase flexibility and intuitively in protocols. He presented an exploder definition for commitments for using in a larger level. In his definition, a new grammar named *CTL* and terms like SC^P for unconditional commitments and SC^C for conditional commitments was added. In fact, *CTL* is a logical tree and commitments are the nodes of tree that organize in tree base on logical regulation in transaction execution time [9].

Narendra represented a contract as a collection of the participants' commitments toward each other. The interactions that take place in a contract are understood in terms of how they operate on the participants' commitments. The operations on a commitment cause its state to change according to a life cycle [10].

Grosof and Poon defined a rule-based approach for e-contracting. In their approach a contract is a set of activities that can be decomposed into sub-activities. The terms of contracts uses a set of commitments for execute operation by agents. Algorithm uses a coordination method to manage agent activities [11].

C. Overview on Consistency in Web Services

Choi et al. presented a mechanism to insure consistency for web services transactions. This mechanism recognize inconsistent states of transactions and replace them with consistent states. Mechanism operation is designed by a waiting graph of web services transactions and a coordinator that check waiting graph. If coordinator is certified about deadlock lack, allow transaction to execute. Also if deadlock occurred, coordinator recognized a safe state by using waiting graph and replace it instead deadlock state. Based on this mechanism, web service transaction dependency management protocol named WTPD is designed and presented [12].

Reiko et al. suggested an algorithm to guarantee consistency of web services. It receives activity diagram of web service and translate it into CSP to be analyzed for deadlock freedom and protocol consistency [13].

Shan-liang designs a modeled for transaction processing coordination model based on BPEL. In this model a coordinator is used for web services transaction weaving and if deadlock occurred coordinator rollback web services activities [14].

Greenfield et al. developed a protocol for dynamic consistency checking that can be run at the termination of a service-based application [15].

III. COMMITMENT DEFINITION

This section provides a definition of commitments and the types defined for it.

A. Types

Two types of commitments are identified [1]:

1. Social Commitments: guarantee the proper use of the social networks in which the social Web services sign up.
2. Business Commitments: guarantee the proper development of composite Web services in response to users' requests.

B. Structure

Maamar et al. define a formula for Social Commitments based on Fornara's formula. Fornara and Colombetti note that *"...intuitively a social commitment is made by an agent (the debtor) to another agent (the creditor), that some fact holds or some action will be carried out (the content)"*. In addition to this formula, Maamar considers a list of responsibility for social web services. In fact a commitment structure can be designed as: C_{Resp_i} (debtor, creditor, content [|condition]). Condition parameter is optional [3].

Also they define business commitment similar to social commitment with the difference that in these commitments a social web service assigns to a debtor and compositions assign to a creditor [1].

Social commitments defined by Maamar listed as follows [1]:

1. *"Resp1. Collecting any detail (d) in a social network would require indicating the purpose (p) of this collection to this detail's owner (o), represented as Permission(Collect(d, o, valid(p))). Collect is the action, d is for instance a non-functional property like response time, o is the owner of d for instance social Web service, p is the rationale of collecting d, and valid is a function that checks p.*
2. *Resp2. Posting any detail (d) on a social network should be correct. It can be represented as Obligation(Post(d, true)). Post is the action of web service and true is the veracity of d.*
3. *Resp3. Collecting any detail (d) from a social network should not be tampered after information*

[1] Commitment-based SOA

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collection. This responsibility can be represented as Obligation(not-Tamper(d, o, collection(d))). not-Tamper is the operation and collection is a function that checks if collecting d is approved in compliance with Resp1.

4. *Resp4. Signing off from a social network would require the completion of all the pending assignments (ass). It can be represented as Permission(Signoff(status(ass))). Sign-off is the action and status is a function that assesses the progress (e.g., ongoing, complete, and failed) of ass.*
5. *Resp5. Revealing any public detail (d) to the non-members (not(m)) of a social network should not be authorized indefinitely, represented as Obligation(not-Reveal(d, o, m, collection(d))). not-Reveal is the action, m corresponds to the non-members of a social network, and collection is a function that checks if collecting d is approved in compliance with Resp1."*

IV. CONSISTENCY CHECKING ALGORITHM

Maamar et al. formulate Social Networks operation based on Commitment concept. They simulate Web Service actions using Commitments. They define 5 commitment for social networks.

Based on the effect of commitment on social network information, commitments can be categorized to followed groups:

1. Reader Commitments: this category of commitments doesn't change the information of database and usually act as an information collector for other social networks or purpose checker in social web services. Note that the purpose of social web services that use reader commitments must be valid. Also privacy must be protected.
2. Writer Commitments: unlike reader commitments, this category can change the information of database and social networks. They share Information and Post activity on other social networks. So writer commitments are more effective than reader commitments in social web service transactions. Like reader commitments, in writer commitments privacy of information must be controlled.

As regards commitments implement the action of social web services and both reader and writer commitments may act on social networks concurrently, a major problem that must be considered is consistency ensuring of commitments in social web services.

For achieve this consistency, commitment must have priority property. Because of:

1. Sometimes, if two or several social web services are ready for execution, it is important what action is executed first.
2. Private privacy levels have higher priority than public privacy levels.

Assigning priority to commitments must be accomplished carefully.

To ensure consistency of commitments, three concept are considered as follows:

1. Friend: the commitment are friendly if they are reader commitments. So they are consistent in all states and database is in the safe state.
2. Family: commitments are family if they are writer. In fact they effect on the database and information state.
3. Strange: if commitments neither friend nor family are strange. In this state, commitments may be reader or writer.

Since writer commitments have effect on database and information, so if active commitments of social web services be family or strange with other, conflict may occurred. In this case consistency must be guaranteed and if deadlock happens it would be removed and system need to be recovered.

When a web service sign up in a social network, it is recognized by authority component, if it is accepted, responsibility is assigned to web service and its commitments will be created. This time, consistency checking between active commitments is critical and vital. To guarantee consistency, first current commitment condition is checked towards active commitment. Three conditions may occurred:

1. IsFriend: if current commitment and active commitment are friend, both can execute concurrent.
2. IsFamily: if current commitment and active commitment are family, current commitment would wait until active commitment execution is finished.
3. IsStrange: if current commitment and active commitment are strange, current commitment would wait until active commitment execution finished.

Sometimes several commitments are created concurrent in a time slice. In this state, commitments can be executed based on two policy:

1. FCFS: commitments service based on order input time. This policy is fairness.
2. Priority: commitments service by priority.

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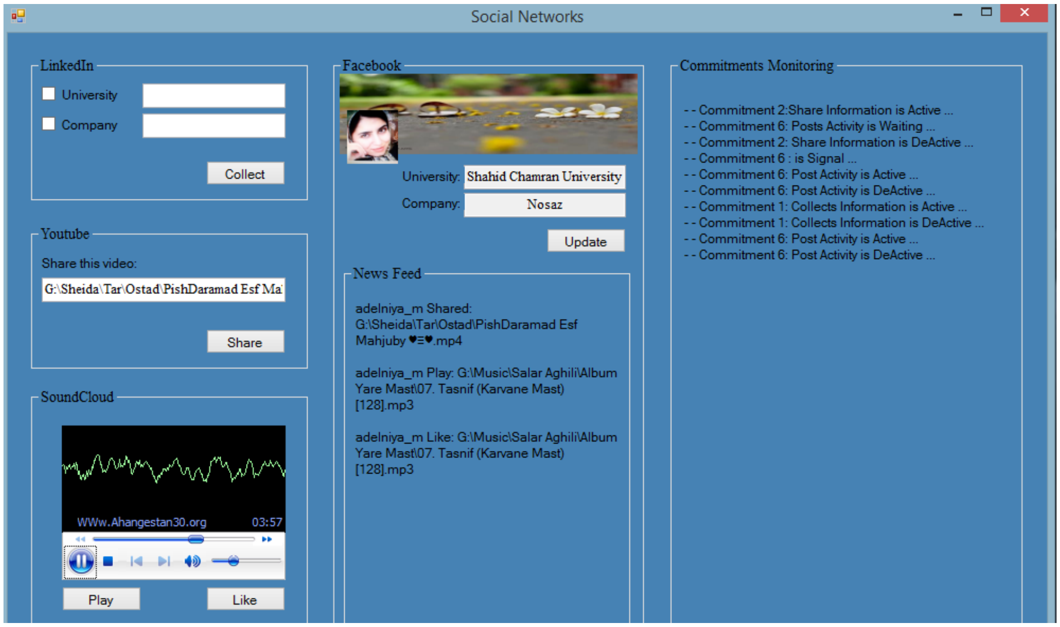

Figure 1. Algorithm Implementation

V. IMPLEMENTATION

An application designed for suggestion algorithm. The commitments architecture that is implemented by Maamar is used as base implementation. In suggestion algorithm, priority, IsReader and IsWriter property have been added to Commitments architecture. A queue is used for waited commitments.

In this application five section considered as follows:

- LinkedIn: this section simulates LinkedIn social network. For simplicity suppose that it collects some information from other social networks only.
- YouTube: this section simulates YouTube social network operation like video sharing.
- SoundCloud: it is a music social network. Some activity like play music, like and share can be done in it.
- Facebook: this section is central social network in this implementation that communicates with 3 other social networks.
- Commitments Monitoring: for monitoring state of commitments in any time, this section designed and shows the number and state of any commitments for all active social web services in a social network.

Experiments:

To carry out experiments, all possible states may occurred in execution of social web services considered and checked.

First, a web service sign up in a social network, if it is authenticated by authority component, it would registered in social network and changed to a social web service. Then one or several responsibility assign to this social web service. Any responsibility has default commitment that act on user account and user information. For a user in social network, if no commitment is active, commitments of responsibility could be active and execute their operations. But if another commitment is active on this user account and information, consistency must be protected. Thus application checks the state of current commitment towards active commitment and decide commitments execute or wait.

VI. CONCLUSION

This study set out to present an algorithm to ensure consistency of commitments in social web services. Also two commitments are considered and added to base commitments for optimizing. This study categorizes commitments into two groups contain reader and writer commitments. Algorithm is designed and described using base concept in social network like “Family” and ”Friend”. For designing algorithm three properties have been added to commitments structure contain reader, writer and priority. If commitments only collect information, called reader commitments and if they affect and change information and database, called writer commitment. Commitments may have three state into each other. They may be friend, family or strange based on their operations. Algorithm manages different states that may occurred in commitment execution of a social web service operation. An application is implemented for correctness checking.

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ISSN 1947-5500

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ISSN 1947-5500

Modeling and Simulation of SRF Control Based Shunt Active Power Filter and Application to BLDC Drive

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Abstract*— With the widespread use of harmonic generating devices, the control of harmonic currents to maintain a high level of power quality is becoming increasingly important. An effective way for harmonic suppression is the harmonic compensation by using active power filter. This paper presents a comprehensive survey of active power filter (APF) control strategies put forward recently. Many control techniques have been designed, developed, and realized for active filters in recent years. This paper presents different types of control techniques like PQ theory, Synchronous reference frame methods for real time generation of compensating current for harmonic mitigation and reactive power compensation. All the techniques are analyzed mathematically and simulation results are obtained which are being compared in terms of its compensation performance with different parameters under steady state condition. The techniques analyzed are the PQ theory, Synchronous Reference Frame Theory (SRF), SRF theory without synchronizing circuit like phase lock loop (PLL) also called instantaneous current component theory and finally modified SRF theory. Simulation results are obtained under sinusoidal balanced voltage source balanced load condition. The comparison and effectiveness of all the methods is based on the theoretical analysis and simulation results obtained with MATLAB employing a three phase three wire shunt active filter test system. Finally shunt active power filter is applied to BLDC drive application. THD plots with and without APF are presented.

Keywords-component; Synchronous Reference Frame, instantaneous current component theory, Modified SRF, Active Filter, Harmonics. BLDC Drive

I. INTRODUCTION

The growing use of non-linear and time-varying loads has led to distortion of voltage and current waveforms and increased reactive power demand in ac mains. Harmonic distortion is known to be source of several problems, such as increased power losses, excessive heating in rotating machinery, significant interference with communication circuits and audible noise, incorrect operation of sensitive loads . Passive filters are traditional method to eliminate harmonics, but with recent developments in power semiconductor switches and converters, coupled with developments in control techniques and analog and digital implementations, active filters are becoming an effective and commercially viable alternative to passive filters. Active filter offer the following advantages: able to cover a wide range of harmonic frequencies; do not contribute resonant frequencies to the network; harmonic attenuation is network impedance dependent. Among the various topologies the shunt active power filter based on voltage source inverter (VSI) is the most common one because of its efficiency. The performance of active power filters depends on the adoptive control approaches. Various current detection methods, such as instantaneous reactive power theory, synchronous reference frame method. The commonness of these methods is the request for generating reference current of APF, either with the load current or the mains current. The commonness of these methods is to control VSI with the difference between real current and reference current.

A flexible and versatile solution to voltage quality problems is offered by active power filters. The basic principle of APF is to utilize power electronics technologies to produce specific currents components that cancel the harmonic currents components caused by the nonlinear load. Currently they are based on PWM converters and connect to low and medium voltage distribution system in shunt or in series. Series active power filters must operate in conjunction with shunt passive filters in order to compensate load current harmonics. Shunt active power filters operate as a controllable current source and series active power filters operates as a controllable voltage source. Both schemes are implemented preferable with voltage source PWM inverters, with a dc bus having a reactive element such as a capacitor. Active power filters can perform one or more of the functions required to compensate power systems and improving power quality.[11]

Types of Active Power filter:

Mainly there are three types of active power filter:

Based on the converter type

VSI Inverter
CSI Inverter

Based on topology

Active Shunt Filter
Active series Filter
Hybrid filter

SHUNT ACTIVE POWER FILTERS

Shunt active power filter compensate current harmonics by injecting equal-but-opposite harmonic compensating current. In this case the shunt active power filter operates as a current source injecting the harmonic components generated by the load but phase shifted by 180o. This principle is applicable to any type of load considered a harmonic source. Moreover, with an appropriate control scheme, the active power filter can also compensate the load power factor. In this way, the power distribution system sees the non linear load and the active power filter as an ideal resistor. [11]

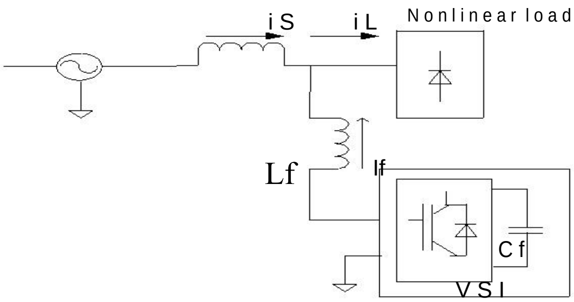


Fig 1. Shunt active power filter

SERIES ACTIVE POWER FILTER

Series APF is connected in series with the distribution line through a matching transformer. VSI is used as the controlled source, thus the principle configuration of series APF is similar to shunt APF, except that the interfacing inductor of shunt APF is replaced with the interfacing transformer. Here operation principle of series APF is based on isolation of the harmonics in between the nonlinear load and the source. This is obtained by the injection of harmonic voltages across the interfacing transformer Series APFs are less.

Here resulting high capacity of load currents will increase their current rating considerably compared with shunt APF, especially in the secondary side of the interfacing transformer. This will increase the I2R losses. Here advantage of series APFs over shunt one is that they are ideal for voltage harmonics elimination.[1]

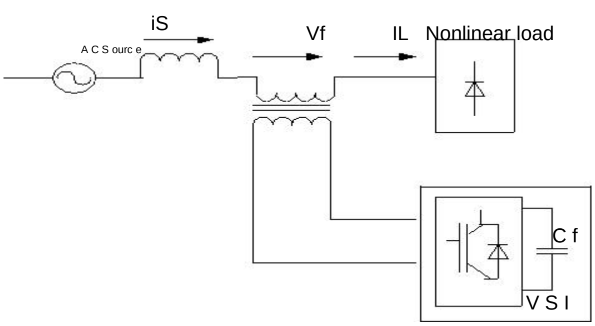


Fig 2. series active power filter [1]

It provides the load with a pure sinusoidal waveform, which is important for voltage sensitive devices (such as power system protection devices). With this feature, series APF is suitable for improving the quality of the distribution source voltage

Several methods including instantaneous real and reactive power theory have been proposed for extracting the harmonic content [2-5]. Among all the methods presented in the literature, the Synchronous Reference Frame method (SRF) is one of the most common and probably it is the best method. It is based on the fact that harmonics change their frequency in a rotating reference frame, and so they are better isolated with high pass filters. The method presents excellent characteristics but it is a little difficult to implement. This paper presents a different modification based on the same principle and compares its performances with sinusoidal source and balanced load condition. The Modified SRF method called, in this paper, Filtered Modified Reference Frame Method (FMRF), because it uses filters and is based on the modified reference frame method [8].

II CONTROL TECHNIQUES

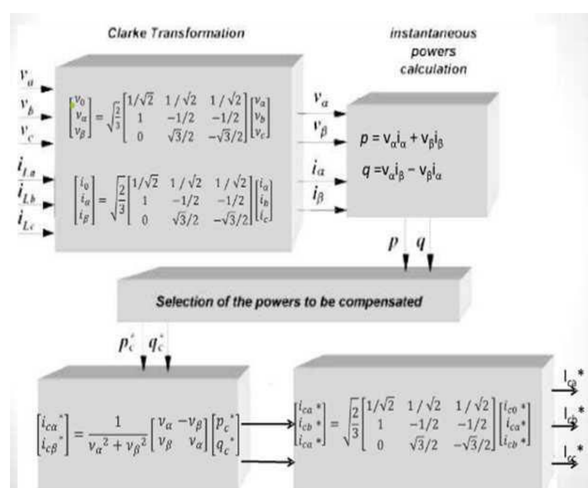
A. *PQ THEORY*

The instantaneous power theory or p-q theory was introduced by *Akagi* in 1983. This method uses algebra transformation also knows as Clarke transform for three phase voltage and current. The three phase voltage and current are converted into α-β using eq. (3) and eq. (4), where i_{abc} are three phase line current and v_{abc} are threephase line voltage.

$$i_{\alpha\beta o} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix} i_{abc} \quad (3)$$

$$v_{\alpha\beta o} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix} v_{abc} \quad (4)$$

Refers to p-q theory, the active power and reactive power for three phase system and the three phase actual current reference for active filter might be given as shown in eq.ns.



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B Synchronous Reference Theory (SRF)

Among the several methods presented in the literature, the Synchronous Reference Frame method (SRF) is one of the most common and probably it is widely used method. This section is organized as to describe succinctly the SRF methods. The three methods presented in this section with some results obtained with the above mentioned methods. The nonlinear load considered is a three-phase diode bridge rectifier.

In the SRF [5], the load current signals are transformed into the conventional rotating frame d-q. If theta is the transformation angle, the transformation is defined by:

$$\begin{bmatrix} x_d \\ x_q \\ x_0 \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \cos(\theta) & \cos\left(\theta - \frac{2\pi}{3}\right) & \cos\left(\theta - \frac{4\pi}{3}\right) \\ -\sin(\theta) & \sin\left(\theta - \frac{2\pi}{3}\right) & -\sin\left(\theta - \frac{4\pi}{3}\right) \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix} \begin{bmatrix} x_a \\ x_b \\ x_c \end{bmatrix}$$

Fig.2 shows the basic configuration of SRF

In the SRF is a time varying angle that represents the angular position of the reference frame which is rotating at constant speed in synchronism with the three phase ac voltages. In the SRF is a time varying angle that represents the angular position of the reference frame which is rotating at constant speed in synchronism with the three phase ac voltages. To implement the SRF method some kind of synchronizing system should be used. In [6] phase-locked loop (PLL) is used for the implementation of this method. In this case the speed of the reference frame is practically constant, that is, the method behaves as if the reference frame's moment of inertia is infinite. The fundamental currents of the d-q components are now dc values. The harmonics appear like ripple. Harmonic isolation of the d-q transformed signal is achieved by removing the dc offset. This is accomplished using high pass filters (HPF). In spite of a high pass filter, a low pass filter is used to obtain the reference source current in d-q coordinates.

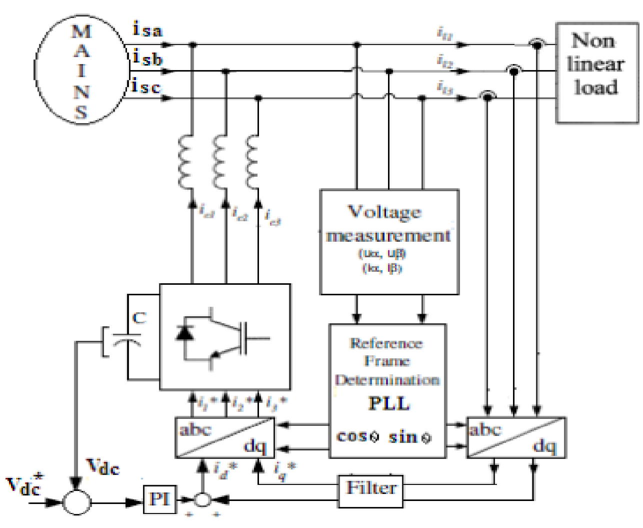

Figure. 3 Basic principal of SRF

C Instantaneous Current Component (i_d-i_q) Theory

The Modified Synchronous Frame method is presented in [7]. It is called the instantaneous current component (i_d-i_q) method. This is similar to the SRF frame method. The transformation angle is now obtained with the voltages of the ac network. The major difference is that, due to voltage harmonics and imbalance, the speed of the reference frame is no longer constant. It varies instantaneously depending of the waveform of the three phase voltage system. In this method the compensating currents are obtained from the instantaneous active and reactive current components and of the nonlinear load. In the same way, the mains voltages $V_{(a,b,c)}$ and the polluted currents $il_{(a,b,c)}$ in α-β components must be calculated as given by (2), where C is Clarke Transformation Matrix. However, the load current components are derived from a synchronous reference frame based on the Park transformation, where represents the instantaneous voltage vector angle (3).

$$\begin{bmatrix} il_\alpha \\ il_\beta \end{bmatrix} = [C] \begin{bmatrix} I_{la} \\ I_{lb} \\ I_{lc} \end{bmatrix}$$

$$\begin{bmatrix} il_d \\ il_q \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} il_\alpha \\ il_\beta \end{bmatrix}, \theta = \tan^{-1}\frac{V_\beta}{V_\alpha}$$

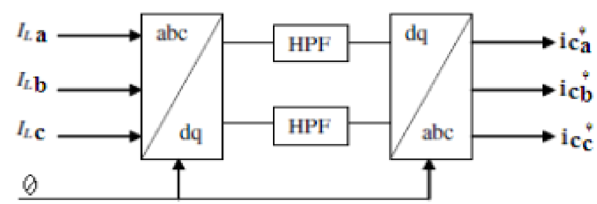

Figure.4 Principal of the synchronous reference frame method

Fig. 3 shows the block diagram SRF method. Under balanced and sinusoidal mains voltage conditions angle θ is a uniformly increasing function of time. This transformation angle is sensitive to voltage harmonics and unbalance; therefore dθ/dt may not be constant over a mains period. With transformation (2) and (3) the direct voltage component is

$$\begin{bmatrix} il_d \\ il_q \end{bmatrix} = \frac{1}{\sqrt{V_\alpha{}^2 + V_\beta{}^2}} \begin{bmatrix} V_\alpha & V_\beta \\ -V_\beta & V_\alpha \end{bmatrix} \begin{bmatrix} il_\alpha \\ il_\beta \end{bmatrix}$$

$$\begin{bmatrix} ic_\alpha \\ ic_\beta \end{bmatrix} = \frac{1}{\sqrt{V_\alpha{}^2 + V_\beta{}^2}} \begin{bmatrix} V_\alpha & -V_\beta \\ V_\beta & V_\alpha \end{bmatrix} \begin{bmatrix} ic_d \\ ic_q \end{bmatrix}$$

$$\begin{bmatrix} I_{comp,a} \\ I_{comp,b} \\ I_{comp,c} \end{bmatrix} = [C]^T \begin{bmatrix} ic_\alpha \\ ic_\beta \end{bmatrix}$$

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C. Modified (i_d-i_q) Theory

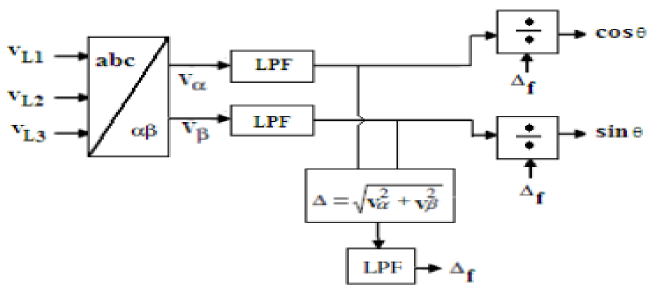

Figure.5 Principal of modified (i_d-i_q) method

The method suggested in this section is based on the modified (i_d-i_q) method (FMRF). The principle is the same. However there are two differences in the determination of the instantaneous position of the rotating reference frame. In spite of using the αβvoltages to calculate the transformation angle, low pass filters (LPF) are used to reduce harmonics of the network signals, and consequently use on the control process approximate sinusoidal waveforms, "Fig.4". This filter is important because the method becomes more insensitive to harmonics on the mains. It will be verified also that the behaviour of the filter will be different concerning to on symmetrical and unsymmetrical conditions.

III MATHAMATIAL MODELING OF BLDC

The three phase star connected BLDC motor can be described by the following four equations in bipolar mode of operation.

The symbol v , i and e denote the phase to phase voltages, phase currents and phase back EMF's respectively, in three phases a, b and c. The resistance R and the inductance L are per phase values and T_e and T_L are the electrical torque and the load torque. J is the rotor inertia, B is a friction constant and w_m is the rotor speed. The back EMF's and the electrical torque can be expressed as

$$v_{ab} = R(i_a - i_b) + L\frac{d}{dt}(i_a - i_b) + e_a - e_b \qquad (1)$$

$$v_{bc} = R(i_b - i_c) + L\frac{d}{dt}(i_b - i_c) + e_b - e_c \qquad (2)$$

$$v_{ca} = R(i_c - i_a) + L\frac{d}{dt}(i_c - i_a) + e_c - e_a \qquad (3)$$

$$T_e = B\omega_m + j\frac{d\omega_m}{dt} + T_L \qquad (4)$$

$$e_a = \frac{K_e}{2}\omega_m F(\theta_e) \qquad (5)$$

$$e_b = \frac{K_e}{2}\omega_m F(\theta_e - \frac{2\pi}{3}) \qquad (6)$$

$$e_c = \frac{K_e}{2}\omega_m F(\theta_e - \frac{4\pi}{3}) \qquad (7)$$

$$T_e = \frac{K_t}{2}\left[F(\theta_e)i_a + F(\theta_e - \frac{2\pi}{3})i_b + F(\theta_e - \frac{4\pi}{3})i_c \right] \qquad (8)$$

K_e and K_t are the back EMF and torque constants.

IV MATLAB/SIMULINK MODELING AND SIMULATION RESULTS

Fig. 6 shows the Matlab/Simulink model of Shunt active power filter. Here simulation is carried out for four cases. In case one APF is simulated using Synchronous Reference Theory (SRF), and case two APF is simulated in BLDC drive application.

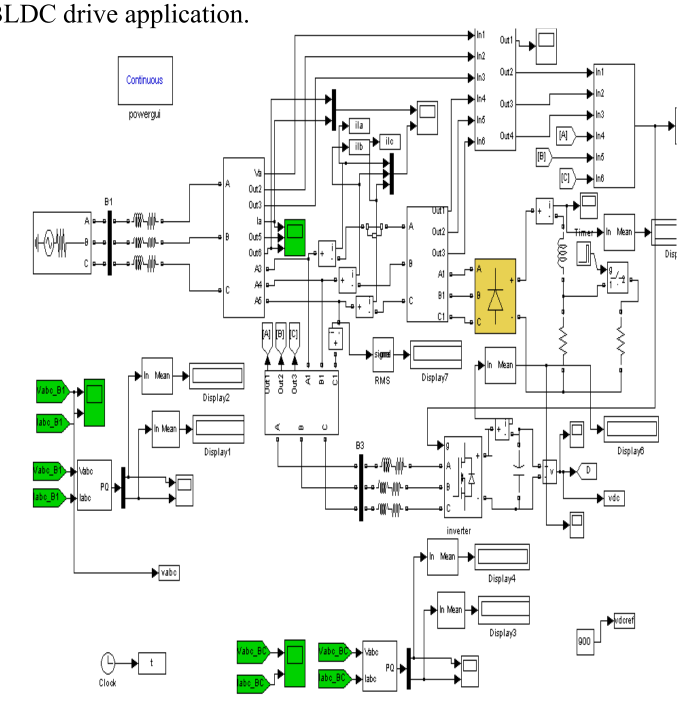

Figure.6 Matlab/Simulink Model of Shunt Active Power Filter

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A Case one

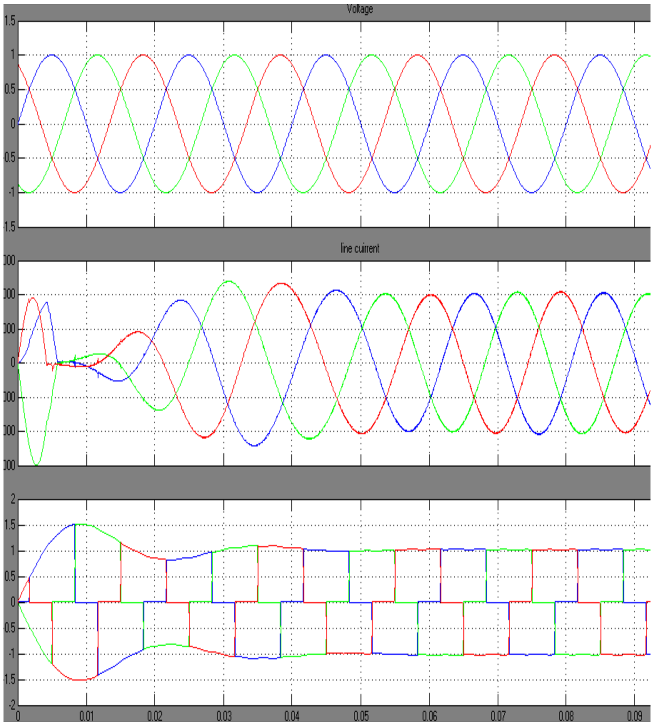

Figure. 7 Simulation results for Synchronous Reference Theory (SRF)

Fig.7 shows the simulation results for SRF theory. It shows three phase source voltage, three phase source currents and three phase non sinusoidal load currents.

B Case two

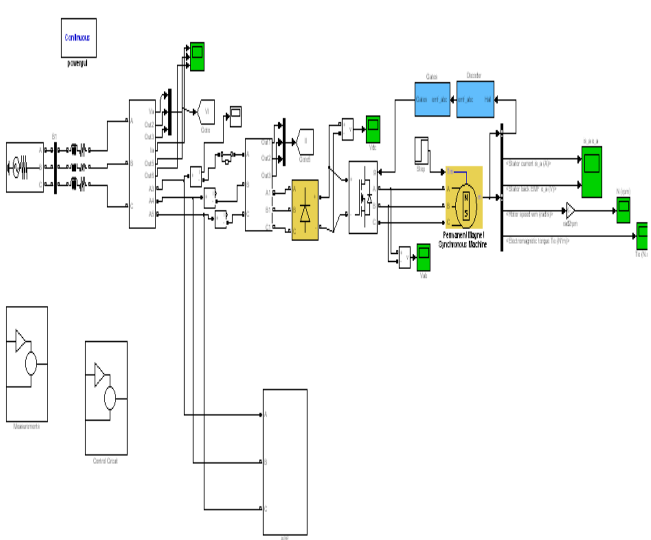

Figure. 8 Matlab/Simulink model of APF BLDC Drive

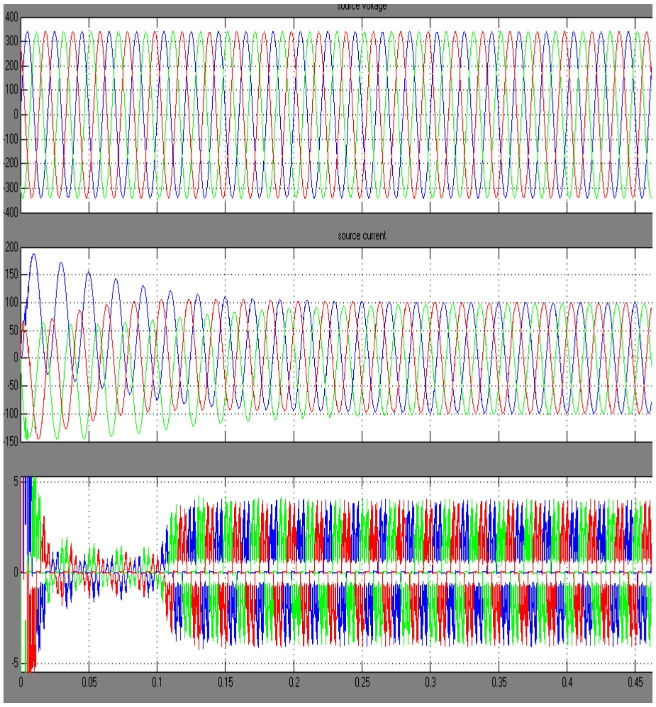

Figure. 9 Simulation results of APF BLDC drive

Fig. 9 shows the simulation results APF. It shows three phase source voltage, three phase source currents and three phase non sinusoidal load currents.

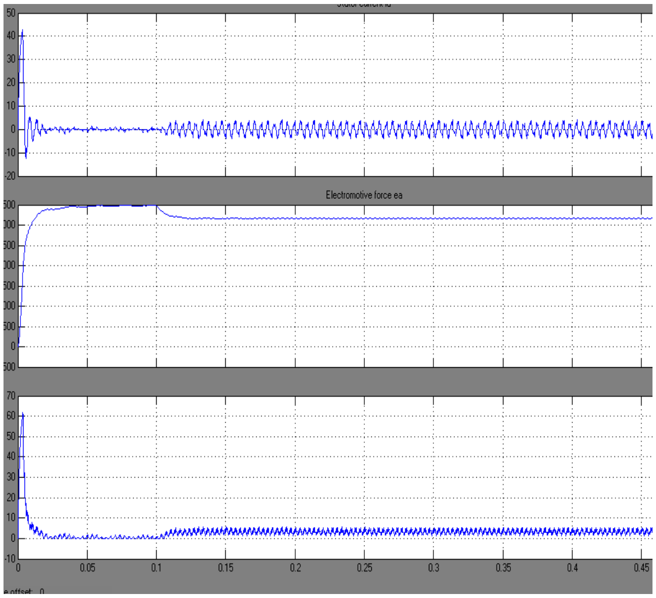

Figure. 10 Simulation results of BLDC

Fig.10 shows the simulation results of APF BLDC Drive it consists of stator currents, motor speed and electromagnetic torque.

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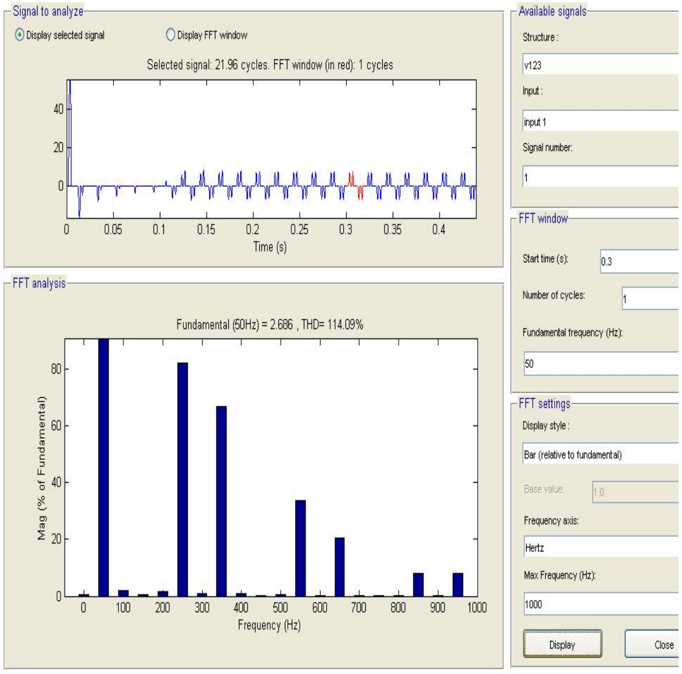

Figure. 11 FFT analysis of source current without APF

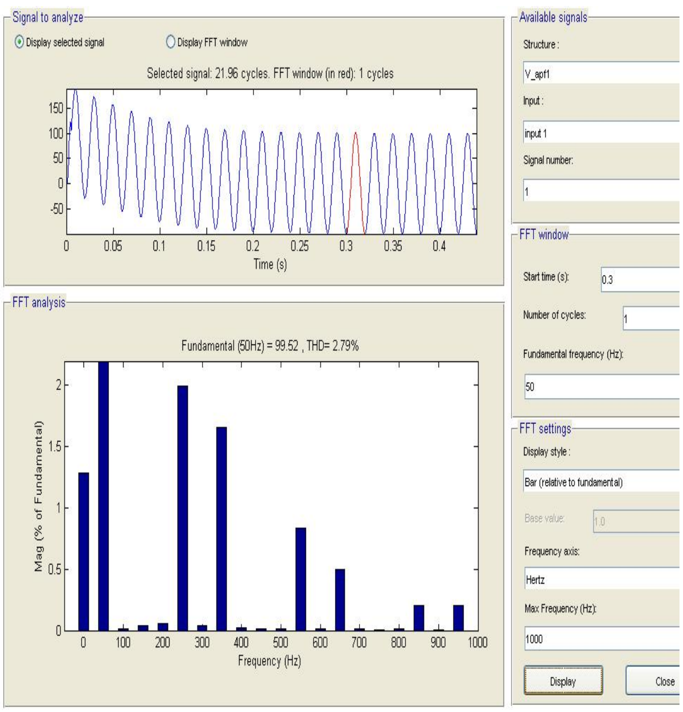

Figure. 12 FFT analysis of source current with APF

Fig.11 shows the source current without APF and harmonic spectrum. Since BLDC motor require square wave current the THD in source current without APF is very high (112%). Fig. 12 shows the source current with APF and harmonic spectrum. From this figure it is clear that with APF the THD is reduced to 2.9%.

V CONCLUSION

This paper presents the compensation performance of all the different SRF techniques under sinusoidal voltage source condition as shown in table-1. Results are similar with gained source THD under IEEE 519, but under various filter type the chebyshev type filter is having superior performance compare to Butterworth filter for all methods. The Synchronous Reference Frame method is one of the most common and performing methods for detection of harmonics in active filters. An Improved Synchronous Reference Frame Method for the control of active power filters was presented. It is called Filtered Modified Reference Frame Method (FMRF) and is based on the same principle as the Synchronous Reference Frame method. However, this new method explores the fact that the performance of the active filter to isolate harmonics depends on the speed of the system that determines the rotating reference frame, but doesn't depend on its position. So, the delay introduced by the ac voltage filters, used for the detection of the reference frame, has no influence on the detection capability of the method. Compared with other methods, this new method presents some advantages due to its simplicity. Finally a BLDC drive application is considered for simulation purpose. THD plots without APF and with APF are presented.

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An Auxiliary Fuzzy Logic Controller for Mitigating Low Frequency Oscillations

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ABSTRACT:

A frequent adverse phenomenon of Low frequency oscillations (LFO) are which develop the risk of instability for the power system. This brief examines the damping functioning of the static synchronous series compensator (SSSC) prepared with an auxiliary fuzzy logic controller (FLC). At the commencement, a customized Heffron-Phillips representation of a single machine infinite bus (SMIB) system set up with SSSC is recognized.

Keywords: Low frequency oscillations (LFO), SSSC, SMIB power system, Heffron-Phillips model, fuzzy logic damping controller.

I. INTRODUCTION

As power systems are inter-connected, utilities have achieved more reliability and economical practicability. In spite of this, low frequency oscillations (LFO) are one of the direct results of the large interconnected power systems. The power oscillations may come up to entire rating of a transmission line, as they are superimposed on stable state line flow. Hence, these oscillations would restrict the total and accessible transfer capability (TTC and ATC) by requiring higher safety margins. These electromechanical modes of oscillations are usually scantily damped which may strengthen the risk of instability of power system. Thus, in turn to maintain the stability of the entire system, it is urgent to damp the electromechanical oscillations as soon as probable.

Quite a lot of different procedures have been suggested to alleviate the oscillations in the power system. For quite a lot of years, power system stabilizer (PSS) has been one of the traditionally devices employed to damp out the oscillations. It is show up that during some operating conditions, PSS may not mitigate the oscillations operatively; hence, other operative alternatives are essential in accumulation to PSS.

On the other hand, the advent of flexible ac transmission system (FACTS) devices has led to a new and more resourceful approach to control the power system in a desired way. The static synchronous series compensator (SSSC) is one of the series FACTS devices based on a solid-state voltage source inverter which generates a controllable ac voltage in quadrature with the line current. By this way, the SSSC emulates as an inductive or capacitive reactance and hence controls the power flow in the transmission lines. In, authors have advanced the damping function for the SSSC.

Here the FLC integrates qualitative and quantitative familiarity about the system operation through some pecking turn. To be more precise, fuzzy logic imparts a general concept for description and measurement of systems. Most of fuzzy logic systems encode human reasoning into a program in turn to arrive at decisions or to control a system. Fuzzy logic comprises fuzzy sets, which is a way of representing non-statistical uncertainty along with approximate reasoning and in fact includes the operations employed to make inferences.

This document addresses the application of a supplementary FLC to attenuate power oscillations by SSSC. The investigation is carried out for a single machine infinite bus the linearized Heffron-Phillips representation of the examined plant is evolved.

The UPFC is a combination of a static synchronous compensator (STATCOM) and a static synchronous series compensator (SSSC) which are coupled via a common dc link, to allow bi-directional flow of real power between the series output terminals of the SSSC and the shunt output terminals of the STATCOM, and are controlled real and reactive series line compensations without an external electric energy source. The UPFC, by means of angularly unconstraint series voltage injection, is able to control, concurrently or selectively, the transmission line voltage, impendence and angle or alternatively, the real and reactive power flow in the line. The UPFC may also provide independently controllable shunt reactive compensation.

II. POWER SYSTEM PROTOTYPE

This fragment is dedicated to extract an exact linearized Heffron-Phillips representation for the inspected power system. As reffered in Fig. 1, a single machine infinite bus (SMIB) system set up with SSSC is considered as the sample power system. A uncomplicated SSSC consisting of a three-phase GTO-based voltage source converter (VSC) is incorporated in the transmission line. It is assumed that the SSSC functioning is based on the well known pulse width modulation (PWM) technique. For the SSSC, Xsct is the transformer leakage reactance; V_{INV} is the series injected voltage; C is the DC link capacitor; *V*DC is the voltage at DC link; m is amplitude modulation index and ψ is the phase angle of the series injected voltage.

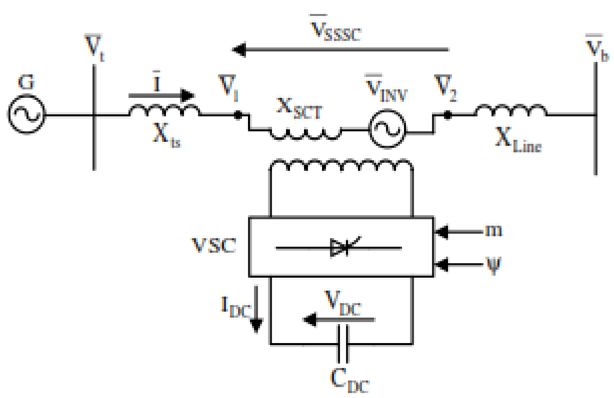

Fig. 1 A single machine infinite bus power system with a SSSC

A. *Nonlinear Dynamic Representation of the Power System with SSSC*

As the present step, a nonlinear dynamic representation for the examined system is derived by neglecting the resistance of all the components including generator, transformer, transmission line, and series converter transformer. The equations specifying the dynamic functioning of the SSSC can be written as follows.

$$\bar{I} = I_d + jI_q = I\angle\varphi$$

$$\overline{V_{INV}} = mkV_{DC}(\cos\psi + j\sin\psi) = mkV_{DC}\angle\psi\,,$$
$$\psi = \varphi \pm 90$$
$$\frac{dV_{DC}}{dt} = \frac{mk}{C_{DC}}(I_d\cos\psi + I_q\sin\psi) \qquad (1)$$

Where k is the predetermined ratio between the converter AC and DC voltages and is dependent on the inverter structure. For an uncomplicated three-phase voltage source converter k is equal with 3/4. Most of the times, SSSC performs as a pure capacitor or inductor; hence, the only main controllable parameter for SSSC is the amplitude modulation index *m*.

For the exertion at hand, the IEEE Type-ST1A excitation system is considered. Fig. 2 displays the block diagram of the excitation system where the terminal voltage Vt and the reference voltage Vref are the input signals. KA and TA are the gain and time constant of the excitation system respectively.

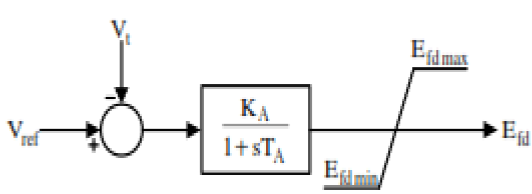

Fig. 2 IEEE Type-ST1A excitation system

The dynamic representation of the power system in Fig. 1 would be as follows.

$$\dot{\delta} = \omega_0(\omega - 1) \qquad (2)$$
$$\dot{\omega} = \frac{P_m - P_e - P_D}{M} \qquad (3)$$
$$\dot{E'}q = \frac{(-E_q + E_{fd})}{T'_{do}} \qquad (4)$$
$$\dot{E}_{fd} = \frac{-E_{fd} + K_A(V_{ref} - V_t)}{T_A} \qquad (5)$$
$$\dot{V}_{DC} = \frac{3m}{4C_{DC}}(I_d\cos\psi + I_q\sin\psi) \qquad (6)$$

Where

δ : Rotor angle of synchronous generator in radians

ω : Rotor speed in rad/sec

Pm : Mechanical power input to the generator

Pe : Electrical power of the generator

$PD = D(\omega - 1)$, D : Damping coefficient

Eq' : Generator internal voltage

$E\,fd$: Generator field voltage

$I\,d$: d-axis current

$I\,q$: q-axis current

B. *Linear Dynamic Representation of the Power System with SSSC*

The linear Heffron-Philips representation of an SMIB system including SSSC can be extracted by linearizing the nonlinear representation around a nominal operating point.

$$\Delta\dot{\delta} = \omega_0\Delta\omega \qquad (7)$$
$$\Delta\dot{\omega} = \frac{(\Delta P_m - \Delta P_e - D\Delta\omega)}{M} \qquad (8)$$
$$\Delta\dot{E}'_q = \frac{(-\Delta E_q + \Delta E_{fd})}{T'_{do}} \qquad (9)$$
$$\Delta\dot{E}_{fd} = \frac{-\Delta E_{fd} + K_A(\Delta V_{ref} - \Delta V_t)}{T_A} \qquad (10)$$
$$\Delta\dot{V}_{DC} = K_7\Delta\delta + K_8\Delta E'q + K_9\Delta V_{DC} + K_{DCm}\Delta m \qquad (11)$$

Where

$$\Delta P_e = K_1\Delta\delta + K_2\Delta E'q + K_{pDC}\Delta V_{DC} + K_{pm}\Delta m \qquad (12)$$
$$\Delta E_q = K_4\Delta\delta + K_3\Delta E'q + K_{qDC}\Delta V_{DC} + K_{qm}\Delta m \qquad (13)$$
$$\Delta V_t = K_5\Delta\delta + K_6\Delta E'q + K_{vDC}\Delta V_{DC} + K_{vm}\Delta m \qquad (14)$$

Figure 3 exhibits the transfer function representation for the customized Heffron-Phillips representation of the SMIB system with SSSC.

C. *State Space Representation of Linear Representation*

The customized Heffron-Phillips representation can be reoffered in state-space as:

$$\dot{X} = AX + BU \qquad (15)$$

Where X and U are defined as the state vector and control vector respectively.

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$$X = [\ \Delta\delta \quad \Delta\omega \quad \Delta E'q \quad \Delta E_{fd} \quad \Delta V_{DC}\ ]^T \tag{16}$$

$$U = [\ \Delta m\ ] \tag{17}$$

With respect to (7)-(15), the corresponding system matrix namely A , and the control matrix namely B , are attained for the inspected power system.

$$A = \begin{bmatrix} 0 & \omega_0 & 0 & 0 & 0 \\ -\frac{K_1}{M} & -\frac{D}{M} & -\frac{K_2}{M} & 0 & -\frac{K_{pDC}}{M} \\ -\frac{K4}{T'_{do}} & 0 & -\frac{K_3}{T'_{do}} & \frac{1}{T'_{do}} & \frac{-k_{qDC}}{T'_{do}} \\ -\frac{K_A K_5}{T_A} & 0 & -\frac{K_A K_6}{T_A} & -\frac{1}{T_A} & -\frac{K_A K_{vDC}}{T_A} \\ K7 & 0 & K8 & 0 & K9 \end{bmatrix} \tag{18}$$

$$B = \begin{bmatrix} 0 \\ -K_{pm} \\ -K_{qm} \\ -K_{vm} \\ K_{DCm} \end{bmatrix} \tag{19}$$

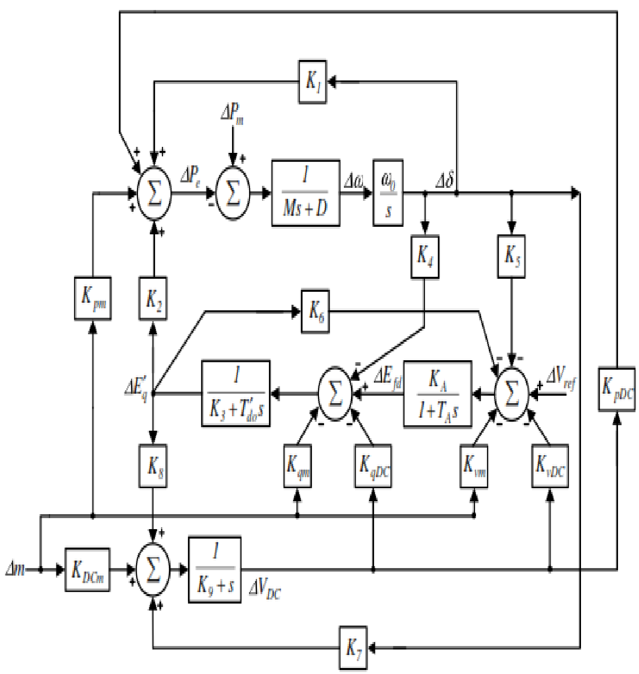

Fig. 3 Heffron-Phillips representation of the single machine infinite bus power system with SSSC

D. *Calculation of the Heffron-Phillips Representation Constants*

The nominal operating point for the power system is set to the given values.

$$P_e = 0.8\,pu,\ \ Q_e = 0.144\,pu,\ V_b = 1\,pu$$

The Heffron-Phillips representation constants are calculated based on the given values for the nominal operating point and some other data which are show up in the Appendix A. Also the parameters of SSSC are given in the Appendix B. Ultimately; Appendix C gathers all of the constants computed for the system representation reoffered in Fig. 3.

III. APPLICATION OF DAMPING CONTROLLERS

A. *Conservative Proportional-Integral (PI) Controller*

The damping controllers are premeditated so as to impart an extra electrical torque in phase with the speed deviation in turn to develop the damping of oscillations. Fig. 4 shows the conservative PI controller structure. With respect to this figure, it can be observed that the first block compares the generator rotor speed with the reference speed. In the follow-up, the error is fed to a PI controller to generate the proper amplitude modulation index for the SSSC converter.

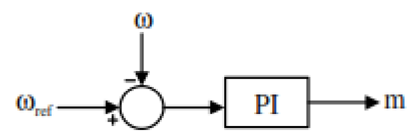

Fig. 4 Conservative PI damping controller

B. *Auxiliary Fuzzy Logic Damping Controller*

As vindicated in the preceding fragments, although the PI controllers present simplicity and ease of application, their functioning deteriorates when the system conditions vary widely or large disturbances occur. The centroid defuzzyfication technique was employed in this fuzzy controller.

Fig. 5 make obviouss the FLC structure. In this case, a two–input, one–output FLC is considered. The input signals are angular velocity deviation ($\Delta\omega$) and load angle deviation ($\Delta\delta$) and the resultant output signal is the amplitude modulation index (Δm) for SSSC converter.

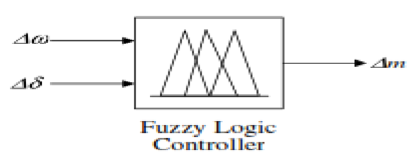

Fig. 5 Fuzzy logic damping controller structure

The offered FLC has a very uncomplicated structure. The membership functions of the input and output signals are revealed in Fig. 6. There are two linguistic variable for each input variable, including, “Positive” (P), and “Negative” (N). On the other hand, for the output variable there are three linguistic variables, namely, “Positive” (P), “Zero” (Z), and “Negative” (N).

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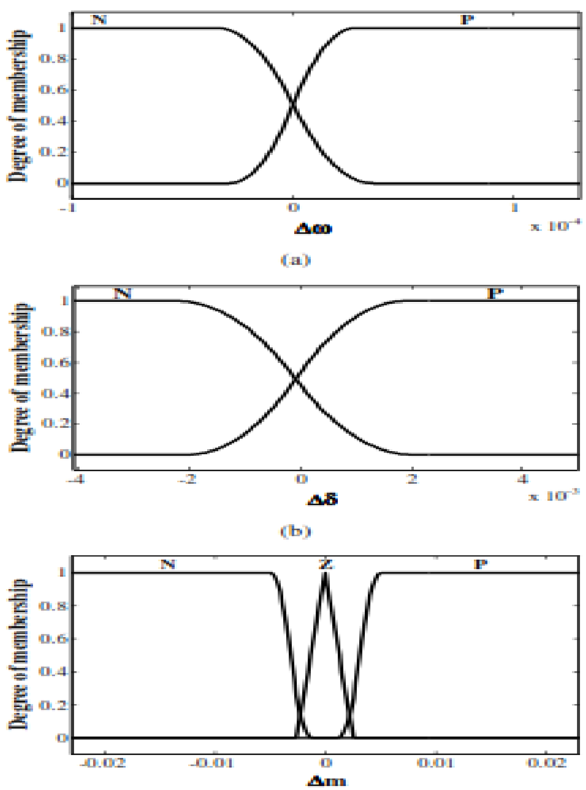


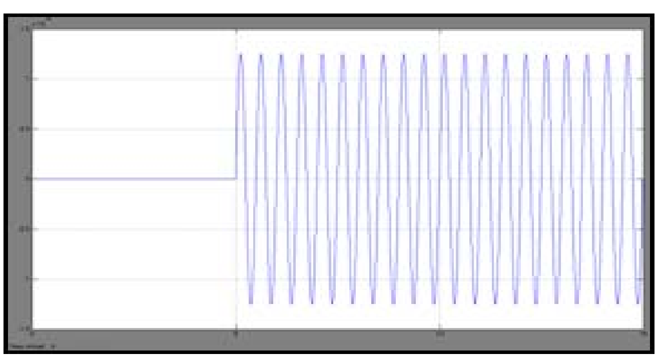
Fig. 6 (a), (b) inputs membership function, (c) output membership function

The rules employed for the FLC are chosen as follows:

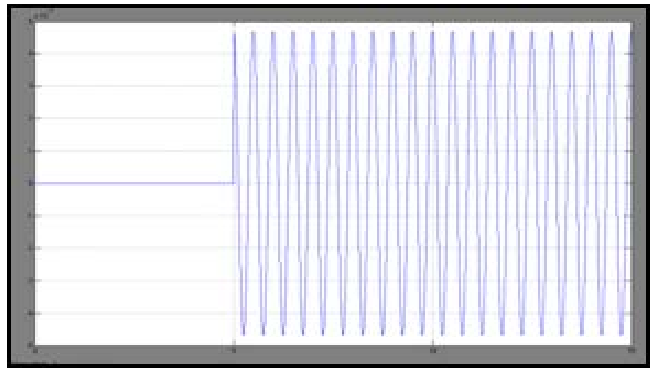
If $\Delta\omega$ is P **and** $\Delta\delta$ is P, **then** Δm is P.
If $\Delta\omega$ is P **and** $\Delta\delta$ is N, **then** Δm is Z.
If $\Delta\omega$ is N **and** $\Delta\delta$ is P, **then** Δm is Z.
If $\Delta\omega$ is N **and** $\Delta\delta$ is N, **then** Δm is N.

IV. SIMULATION RESULTS

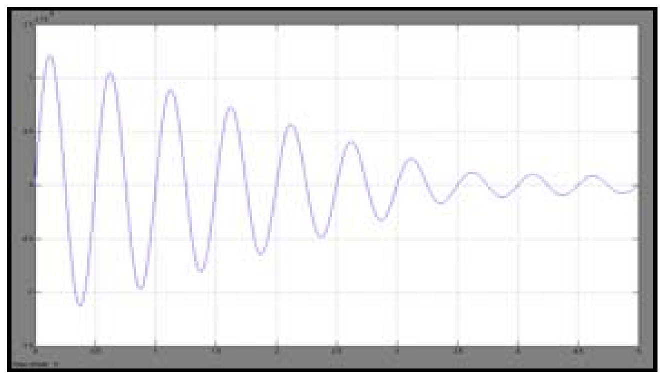
Simulation has done for the system with only heffron model and with PI controller and also with Fuzzy controller. The results validate the efficiency of the suggested fuzzy logic damping controller and its enhanced functioning is hassled.



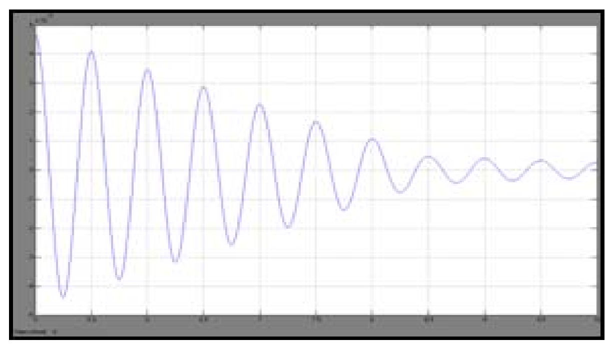
Dwo with only Heffron model



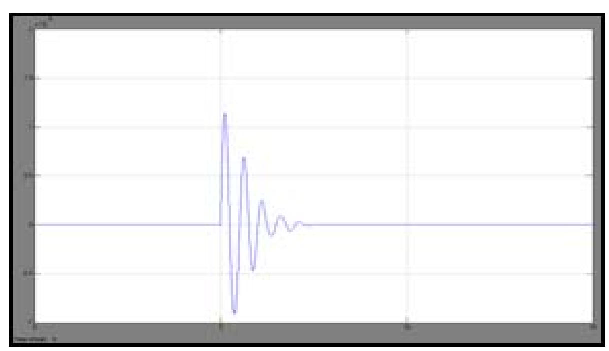
Ddelta with only Heffron model



Dwo with PI controller



Ddelta with PI controller



Dwo with Fuzzy controller

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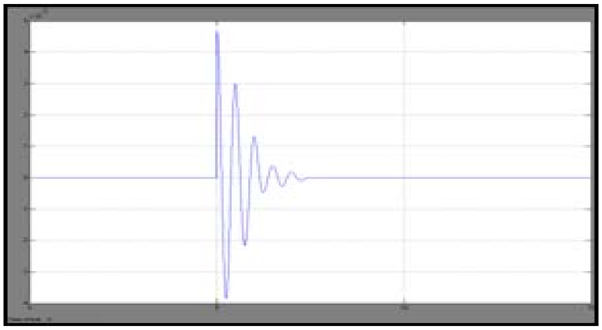
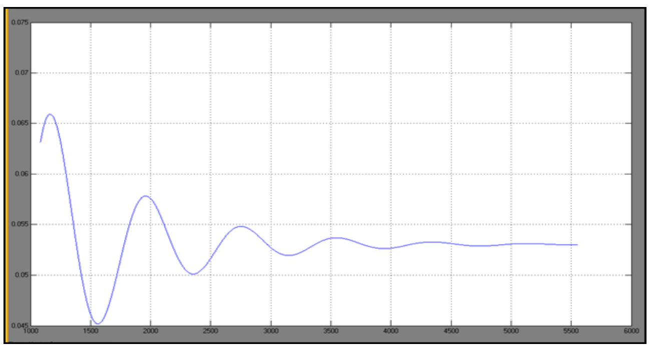
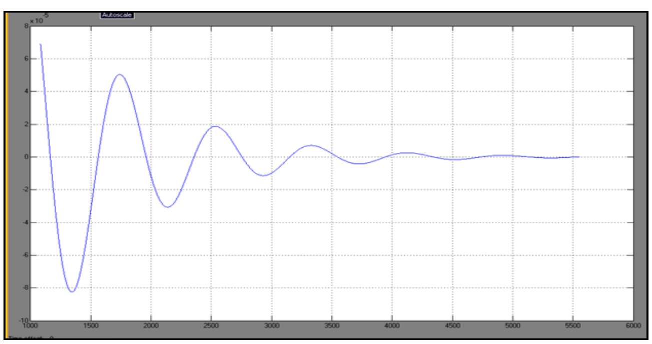


Ddelta with Fuzzy controller

The proposed system has replaced the SSSC with UPFC to get more efficient results which are shown below:



Dwo of UPFC with Fuzzy controller



Ddelta of UPFC with Fuzzy controller

V. CONCLUSION

This project provides an exact investigation to acquire a detailed linearized Heffron-Phillips representation for a single machine infinite bus power system prepared with an SSSC to study LFO damping with an auxiliary FLC. In the follow-up, two types of controllers, namely, the conservative PI and the FLC were premeditated to damp the system oscillations.Simulation results validate the efficiency of the suggested fuzzy logic damping controller and the model is designed with UPFC. The results show that the system with UPFC is more stable than with the SSSC.

APPENDIX A

POWER SYSTEM PARAMETERS

Generator:

M=2H=6 MJ/MVA, D=0, T'do=5.044s, Xd=0.1pu, Xq=0.06pu, X'd=0.025 pu f0=60 Hz, ω0=2πf0

Excitation system:

KA=5, TA=0.005 s

Transmission line and transformer reactances:

XLine=0.2 pu, Xts=0.2 pu

APPENDIX B

THE SSSC PARAMETERS

CDC=1 pu; VDC=0.5 pu; m=0.15; XSCT=0.1 pu

APPENDIX C

HEFFRON-PHILLIPS REPRESENTATION CONSTANTS

*K*1=1.9014; *K*2=0.6735; *K*3=1. 1429

*K*4=0.0498; *K*5=-0.0127; *K*6=0. 9517

*K*7=-0.1759; *K*8=0.0302; *K*9= 1.402×10-4

*K*DCm=-0.4255; *K*pDC=0.0244; *K*qDC=0.0106; *K*vDC= -0.0035

*K*pm=0.0839; *K*qm=0.0354; *K*vm=-0.008

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Power Flow Enhancement using Fuzzy based power converter connected in DG fed Distribution network

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***Abstract*---This paper presents the distributed generating (DG) systems employed in distribution systems interfaced by design of proportional-integral controller (PI) and fuzzy logic controller (FLC) based 3-phase power converter. To maintain smooth transfer of power flow in distribution systems for different load conditions, the step-up converter must regulate its DC voltage and allows the VSI to stabilize terminal voltage. The power flow between the grid and the DG is controlled by the power /voltage control methods and phase-locked loop (PLL) algorithm is used to synchronize the grid and the DG. Additionally, a set of simulations are performed for different load types and its working conditions by using fuzzy logic controller and compared with classic PI controllers. The system is designed and simulated using MATLAB/ Simulink Software.**
Keywords-distributed generating (DG), fuzzy logic controller (FLC), islanding mode, 3-phase power converter, phase-locked loop (PLL), proportional-integral controller (PI),and voltage source inverter (VSI).

I. INTRODUCTION

Many developing countries are now widely recognised that the fossil fuels and other resources that are presently used in generation of electrical energy, may not be sufficient or suitable as a solution to the growing problems of energy demand [1].As the load demand increases the complexity of the distribution network increases thereby, maintain power flow and voltage becomes complex in the radial distribution network.

Apart from the consequent reduction in size of generating plants and complexity of distribution network, The Distributed Generation is a new trend that emerges for providing electric power as required for the demand [2]. These DG systems based on renewable energy resources [2] such as (photo voltaic, wind energy and fuel cells [1]) are well encouraged because of their low environmental impact and high technical advantages such as improvement in voltage levels and reduction in power losses, when these DG systems are installed in radial distribution lines[4].The DG systems are installed in the grid, and then the distribution system becomes an active system with both energy generation and consumption, the DG must supply locally and its working regime .The DG operates at high performances requires a detailed evaluation of feeder [5] in which it is installed and along with the assessment of load type. Without this analysis the insertion of DG into the distribution system causes inevitable effects such as transient effects due to switching operations, changing in short-circuit levels, lower margin of stability, inversion of power flow through the system and islanding a part in the system [6].

The DG operation should be in the limits established by the international standards for the following parameters: harmonic distortion, voltage imbalance, voltage fluctuations, and fast transients, and whether the load is linear or non-linear.

The DG systems are installed in the grid by interfacing with the power converter, the power fed from DG is converted into AC and the operation of the system is done by maintaining the DC link voltages. This voltage control provides the capability to supply different kinds of loads (such as linear, non-linear it may be balanced or un-balanced loads) to the DG systems. The power flow in the DG fed system is determined by controlling the voltage amplitude and angle of displacement between the DG voltage and the grid voltage.

This paper analyses the effects caused by the DG sources inserted into the distribution system by different loads considered. Section II details the components in the system considered. Section III explains the synchronization of DG with grid. Section IV details the Fuzzy logic controller Section V shows the simulation analysis for different cases and Section VI presents the conclusion.

Fig.1 shows the diagram of the system interfacing DG systems into a specific feeder in the grid through a 3-phase power converter.

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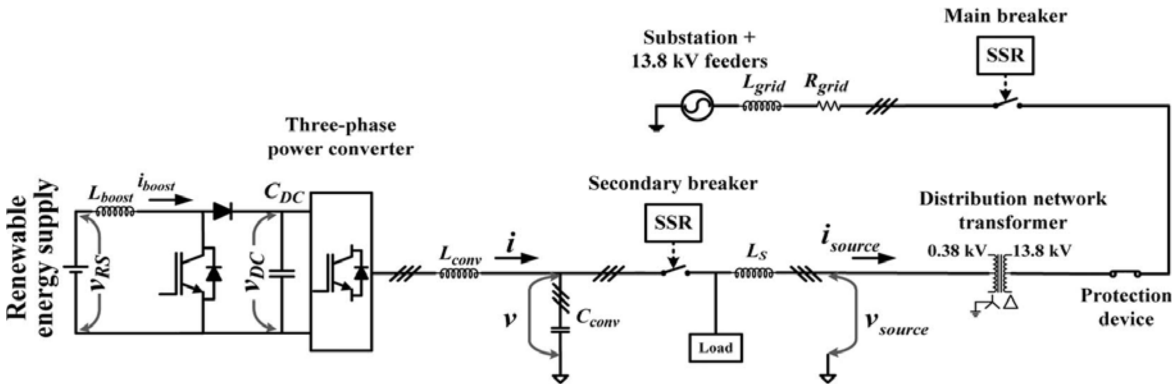

Fig.1 General Diagram of the Distributed Generation System.

II. COMPONENTS IN THE SYSTEM

A. DG System :

The DG systems based on renewable energy resources are used to generate power and these are installed directly into the grid, nearer to load in order to share the load demand with the utility. The DG system of 5000kVA capacity is connected to a specific feeder in the distribution network through a power converter. Here the DG systems represent a secondary source, while the grid system is primary.

B. Grid System :

In the simulations the complete system, considering DG and the grid is found in 1547 standards [7] developed by the Institute of Electrical and Electronics Engineers (IEEE). This standard is the primary interconnection standard; the approval of this standard should influence the electrical distribution system to operate with distributed generators and two-way flow of electric energy.

The main grid system considered is a 13.8-kV feeder connected to 69-kV radial line through a 69/13.8- kV transformer, as shown in the above Fig.1.In order to insert the DG in the distribution network, a 13.8/0.38 kV distribution network transformer is required to equalize the voltage levels in the grid.

In the simulations, the line model employed is taken into account the Bergeron's travelling wave method, used by the electromagnetic transient program (EMTP). This method is used for constructing transmission lines, which utilizes wave propagation phenomenon and line end reflections.

C. 3-Phase Power Converter:

The power obtained from different DG's can be used to fulfil the requirements for many applications. The applications differ according to the load requirements, and the conversion of DG output is done through the power electronics interface between the DG and the grid. Here a 3-phase power converter considered is a two stage converter.

1. *DC-DC Converter:*

The DC-DC step up converter equalize the dc-link voltages, it is used as an interface between the dc source and the dc link of the three phase power converter. The converter diagram is as shown in the Fig 2. It improves the dc voltage and supplies fast transients of energy, and thereby minimizes the disturbances in the feeder current.

This converter acts as a dc voltage source and the power it delivers is depends on the method of tracking maximum power point (MPPT)[8]of a photo voltaic array, is an essential part of a PV system.

2. *DC-AC converter*:

The voltage source inverter (VSI) acts as a DC-AC converter, it is used to guarantee the power quality delivered to customers and the feeder it is fed. To avoid the disturbances between the converter and the feeder, a phase –locked loop (PLL) algorithm is used.

The block diagram of the DC-AC converter is as shown in the Fig 3.The closed-loop controls of the output current and voltage were implemented in order to guarantee inverter voltage quality.

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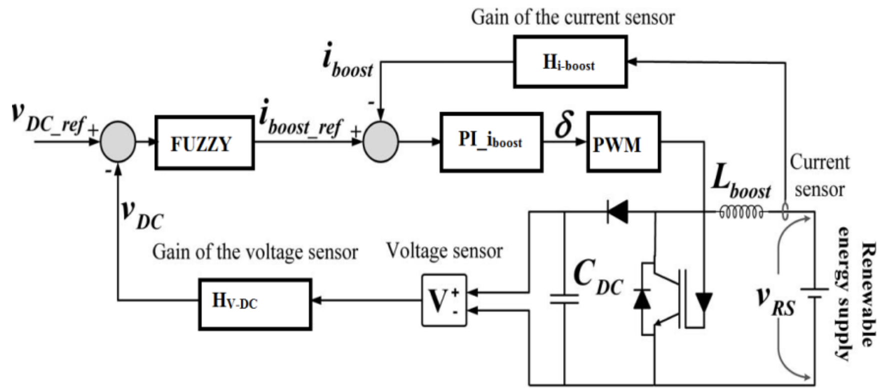

Fig.2 Shows the Block Diagram of the DC-DC Converter.

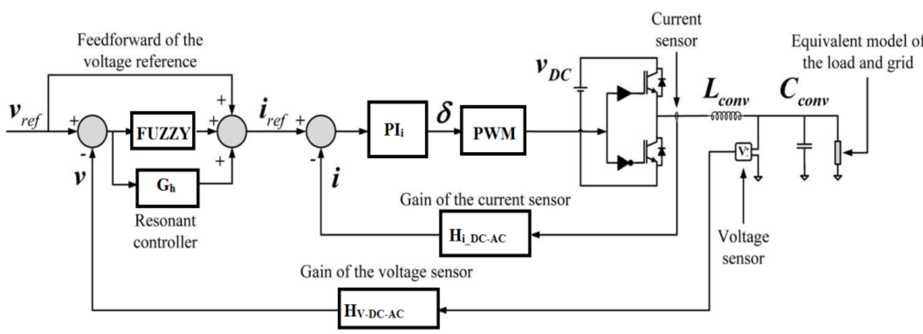

Fig.3 Shows the Block Diagram of the DC-AC Converter.

The parameters in the Table I show the required design parameters of both the converters [2].

TABLE I

Desgin Paramerters of The Converters				
V_{DC} (V)	C_{DC}(μF)	$H_{i\text{-}boost}$	$H_{V\text{-}DC}$	$H_{i\text{-}DC\text{-}AC}$
330	2,800	1/12	1/360	1/12

III. SYNCHRONIZATION ALGORITHM

To insert the DG systems into the grid it is necessary to synchronize both the systems i.e., maintaining voltage magnitude, phase angle of the voltage and the frequency are same.

There are several methods used for grid synchronization [10], among the Zero-Crossing Method and Filtering of Grid Voltages, Phase Locked Loop (PLL) technique is most widely used.PLL Technique is the state-of –the-art of extracting phase angle of the grid voltage. The general description of the PLL algorithm is as shown in the Fig 4.

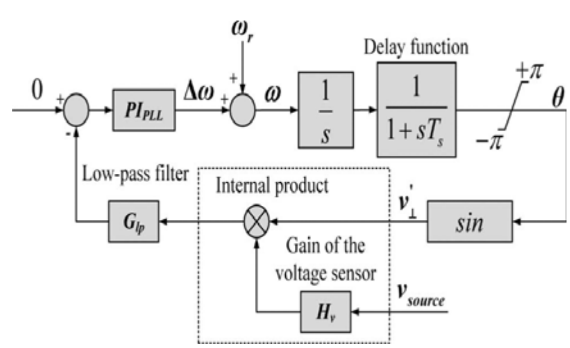

Fig.4 show the general description of the PLL algorithm.

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IV. FUZZY LOGIC CONTROLLER

Fuzzy Logic Controller (FLC) is a fuzzy – logic based control system, it is a non-mathematical decision algorithm that is based on an operator's experience. This controller analyzes analog input values in terms of logical variables that can take on continuous values between 0and 1.The First input of the Fuzzy Logic Controller is error and second input is change in error. Fig.5 shows the Fuzzy logic controller [11].

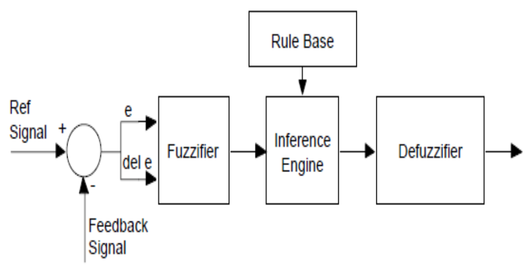

Fig.5 Show the Structure of Fuzzy Logic Controller.

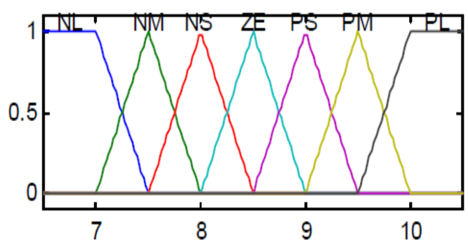

Fig.6 Shows the Membership Functions of the Fuzzy Logic Controller.

Voltage

		NL	NM	NS	ZE	PS	PM	PL
	NL	PL	PL	PL	PL	PM	PS	ZE
	NM	PL	PL	PM	PM	PS	ZE	NS
Del	NS	PL	PM	PS	PS	NS	NM	NL
Volt	ZE	PL	PM	PS	ZE	NS	NM	NL
	PS	PL	PM	PS	NS	NS	NM	NL
	PM	PM	ZE	NS	NM	NM	NL	NL
	PL	ZE	NS	NM	NL	NL	NL	NL

Fig.7 show the Fuzzy Logic Rule table.

1. FUZZIFIER:

Fuzzy Logic uses linguistic variables instead of numerical variables. The process of converting a numerical value into a linguistic label is called "Fuzzification". In a closed loop control system, the error (e) between the reference voltage and the output voltage, and the rate of change of error (Del e) can be named as zero (ZE), positive small (PS), negative small (NS), etc.

Figure 6 shows the member ship functions that are used to Fuzzy inputs. The membership value can take from 0 to 1 for each Linguistic label.

For each of the input and output variables, the following seven Linguistic labels are assigned to the membership functions:

NL= Negative Large
NM =Negative Medium
NS=Negative Small
ZE=Zero
PS=Positive Small
PM=Positive Medium
PL=Positive Large

Once the member ship functions are found for each linguistic label, an intelligent decision process can be made to sense what output should be, is called inference.

2. INFERENCE:

In conventional PI controllers there are control laws, where as the Fuzzy Controller contains rules. Rules are linguistic in nature and they allow the operator to develop a control design in a more familiar human environment. A typical rule can be written as Follows:

If the "error" is negative Large (NL), and the "rate of change of error" is negative Large (NL), then the output is positive large (PL).It is convenient when dealing with large number of inputs, to put rules.

The Fig 7 show the rules done for large number of input combinations. After the rules are evaluated, from each of the output membership function having a membership provides a numerical value called crisp value called "Defuzzification".

3. DEFUZZIFICATION:

DeFuzzification plays an important role in Fuzzy logic based control system. It is the last process of Fuzzy control system in which the Fuzzy inputs, to put rules.

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The Fig 7 show the rules done for large number of input combinations. After the rules are evaluated, from each of the output quantities defined for the output membership functions are mapped into a crisp number.

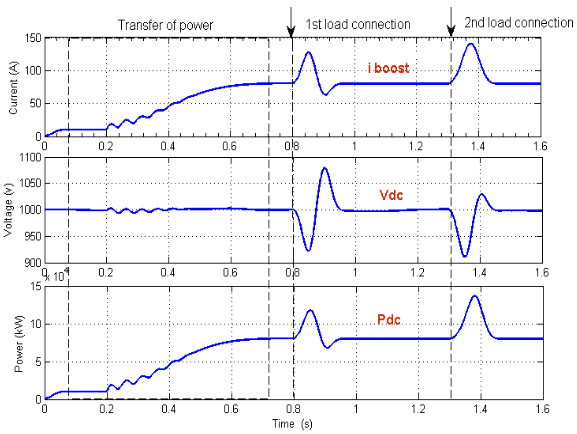

Fig.8 output wave forms of the DG system.

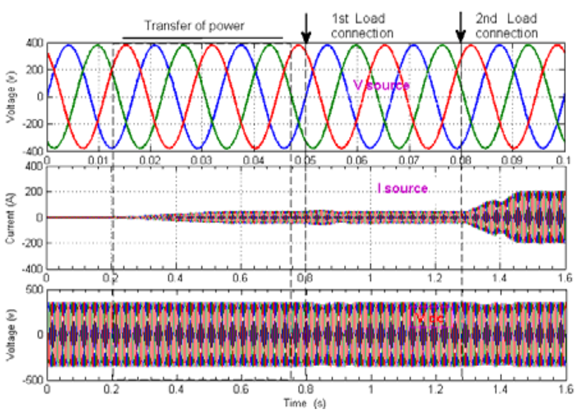

Fig.9 output wave forms of the Grid.

V. SIMULATION ANALYSIS

Simulation was performed by using MATLAB/Simulink software. MATLAB is a high performance language for technical computing and it integrates programming in an easy environment.

A. Connection of DG system into the grid with two Linear loads.

In this case the connection of DG into the grid system is considered and after synchronization procedure, the switch connecting both the DG and the grid system is closed at 0.2 s after minimizing the transient effects, a soft transfer of power is done at 0.2 s. The transfer of power and the minimal disturbances occurred in the grid is observed in the Figs 8 and 9.

After the power transfer, two groups of the resistive loads one Load demanding 70 kW is connected at 0.8s and another load demanding 60kW is connected at 1.3s. The variables subject to fast transients are observed in DG only, and the total harmonic distortion (THD) of the DG voltage is 1.23% only.

B. Connecting Non-Linear Load into the System.

In this case a 3-phase non-linear load demanding 50kVA from the DG is connected into the system. The output wave forms of the Load currents and voltages are zoomed out and are shown in the Figure.

with the PI Controllers the voltage imposed by the VSI is raises to 3% whereas with the use of Fuzzy controllers the voltage is 1.23%.The distortions in the voltage and the current waveforms can be clearly observed in the time interval of 1.96 to 2s as shown in the zoom of the wave forms in Fig10.

C. Islanding Mode Consideration.

Islanding is the mode, obtained by isolating a part of a system from the network. This is an important aspect and in the considered network when a short circuit occurs in the grid, then the protecting devices isolate the grid from the distribution network in order to avoid disturbances, and thereby causing stability problems.

The islanding mode is clearly explained by isolating grid and performing series of events such as, First a balanced 3-phase load was connected to DG at the beginning of the simulation and the changes were observed at 1.8 s. Then another load of 75kW is connected to DG, now a small transfer of power is done by the grid. The output wave forms of the DG and the grid is observed in Fig 11.

D. Islanding and Reconnection to the Feeder .

This is another important aspect, considered when DG systems are involved in the grid. Initially a balanced 3-phase load is connected at the starting of the simulations and a three phase linear load is connected at 1.25 s. The variation in the DG and the Grid powers is as shown in the Fig 12; with the power transfer is zero.

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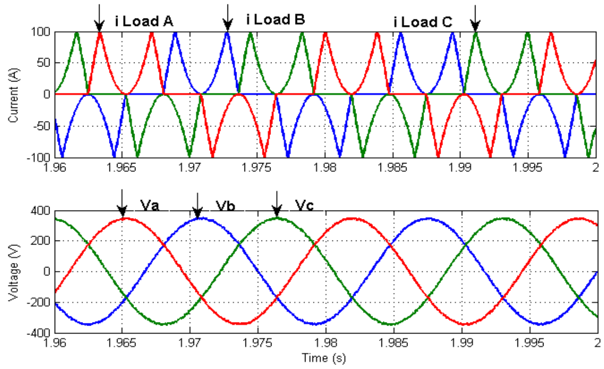
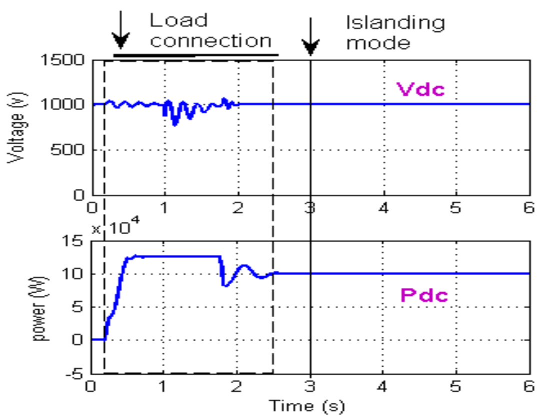
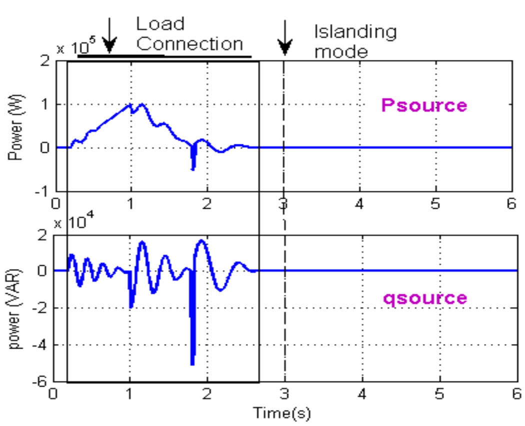


Fig: 10 Output Waveforms of the 3-phase Non-linear Load.

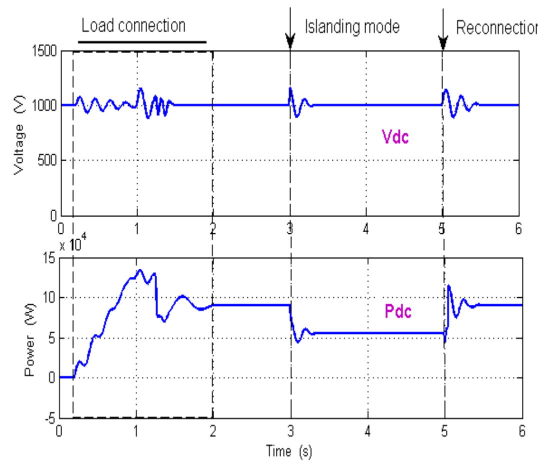


11 (a)

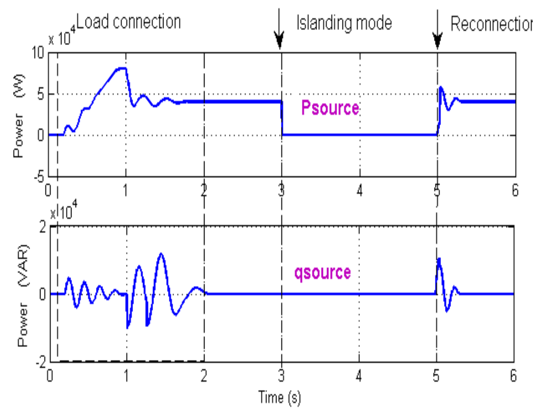


11 (b)

Fig: 11 (a) and (b) show DG and Grid output waveforms in islanding mode.



12 (a)



12 (b)

Fig: 12 shows the Islandng and Reconnection of the Grid into the Distribution Network

I. APPENDIX

Induction Machine Parameters Used in the Simulations

	Simulations	Experimental set-up
Stator resistance (r_s)	0.2761 Ω	5.43 Ω
Rotor resistance (r_r)	0.1645 Ω	6.09 Ω
Stator inductance (L_s)	2.191 mH	17.56 mH
Rotor inductance (L_r)	2.191 mH	17.56 mH
Mutual inductance (M)	76.14 mH	197 mH
Rated voltage	380/440 V	220/380 V
Rated power	20 HP	0.5 HP
Pole pairs (P)	2	2
Inertia (J)	0.1 kgm^2	0.0006 kgm^2
Rated frequency	60 Hz	60 Hz

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CONCLUSION

This paper presents the method of connecting DG systems into the Grid, to supply load requirements and thereby improving the amplitude of voltage level in the distribution network. The analysis was done by considering different types of loads and DG connection, islanding and islanding followed by re-connection modes are analysed. The VSI is used to synthesize DG voltage, and the Fuzzy controller is used as a solution to produce distortion free voltage in the system for all load cases. Simulation results show the effects caused by connecting different loads in the network. With this work the THD are in the range below 2%.

ACKNOWLEDGMENT

The author wants to express her sincere gratitude especially to Mr. C.Ganesh, Working as Assistant Professor in Annamacharya Institute of Technology and Sciences, Razampeta, A.P, INDIA. For his valuable Guidance regarding this work.

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AC TRANSMISSION WITH LOW FREQUENCY FOR RENEWABLE ENERGY SOURCES IN OFFSHORE LOCATION

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***ABSTRACT*-This paper investigates the feasibility of using the low- frequency ac transmission(LFAC)system The LFAC system improves the transmission capacity and distance compared to the conventional AC solution at the nominal frequency, e.g. 50Hz or 60Hz. The main process of this the wind power plant collection system is dc based, and connects to the LFAC transmission line with a 12-pulse thyristor converter. It is estimated that the LFAC system is competitive in the transmission distance up to 160 km. Simulation results are provided to illustrate the system's performance.**

***Keywords* - Cycloconverter; Offshore wind power; Under water power cables; Thyristor Converter; AC Filters**

I. INTRODUCTION

We have greater space availability and better wind energy potential in offshore locations [5], [3]. Offshore wind power plants are expected to represent a significant component of the future electric generation. The integration of offshore wind power plants with the main power grid is a subject of ongoing research [1]–[2]. Presently, high-voltage ac (HVAC) and high-voltage dc (HVDC) are well-established technologies for transmission [4]. The main advantage of the LFAC technology is the increase of power capacity and transmission distance for a given submarine cable compared to 50-Hz or 60-Hz HVAC. This leads to substantial cost savings due to the reduction in cabling requirements and the use of normal ac breakers for protection.

The objective of this paper is to set forth as a design process for an LFAC system for point-to-point transmission. The proposed LFAC system could be built with commercially available power system components, such as the receiving-end transformers and submarine ac cables designed for regular power frequency. Another advantage of the proposed LFAC scheme is its feasibility for multiterminal transmission, since the design of multiterminal HVDC is complicated [6], [9], but the analysis of such an application is not undertaken herein. In summary, LFAC transmission could be an attractive technical solution for medium-distance transmission (i.e., in between HVAC and HVDC) [12]). In LFAC systems, an intermediate-frequency level is used, which is created using a cycloconverter that lowers the grid frequency to a smaller value, typically to one-third its value.

In the proposed system the wind turbines are assumed to be interconnected with a medium-voltage (MV) dc grid, in contrast with current practice, where the use of MV ac collection grids is standard [8]. At the offshore substation (sending end) of the proposed LFAC system, dc collection is becoming a feasible alternative with the development of cost-effective and reliable dc circuit breakers [17], and studies have shown that it might be advantageous with respect to ac collection in terms of efficiency and improved production costs [7]. A dc/ac 12-pulse thyristor-based inverter is used to generate low-frequency (20- or 16 2/3-Hz) ac power, as shown in Fig. 1.

The phase-shift transformer used at the sending end could be a 60-Hz transformer derated by a factor of three, with the same rated current but only one-third of the original rated voltage. At the onshore substation (the receiving end), a thyristor-based cycloconverter is used as an interface between the low-frequency side and the 60 or 50-Hz onshore power grid. Thyristor-based converters can transmit more power with increased reliability and lower cost compared to VSC-HVDC systems. However large filters are necessary at both ends to suppress low-order harmonics and to supply reactive power. Furthermore, the system can be vulnerable to main power grid disturbances.

II. WORKING PRINCIPLE & CONFIGURATION OF LFAC SYSTEM

The proposed system we are assuming a 60-Hz main grid. At the sending end, a medium voltage dc collection bus is formed by rectifying the ac output power of series-connected wind turbines [7]. A dc current source I_w represents the total power delivered from the wind turbines. A dc/ac 12-pulse thyristor-based inverter is used to convert dc power to low-frequency (20-Hz) ac power. It is connected to a three-winding transformer that raises to a higher level for transmission. AC filters are used to suppress the 11th, 13th,

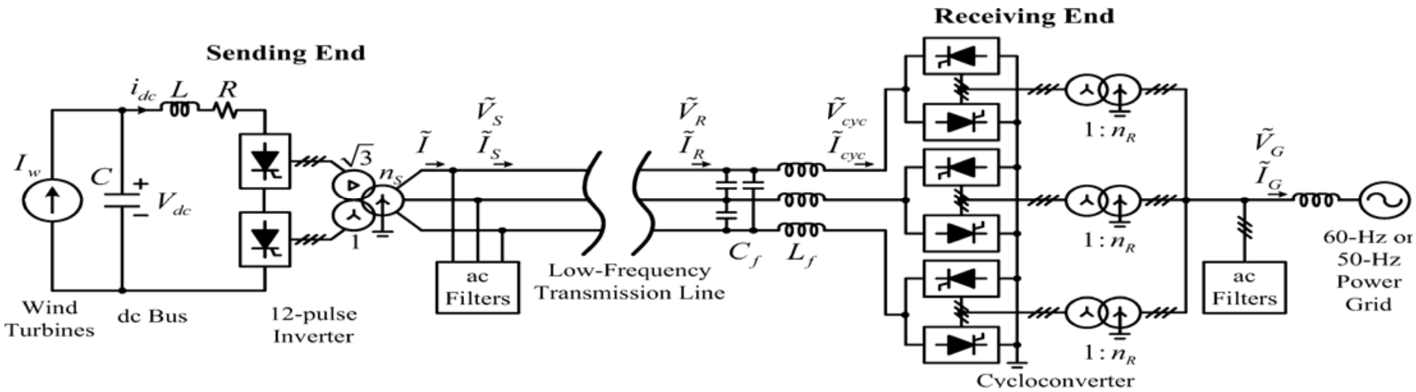

Fig. 1. Configuration of the proposed LFAC transmission system

and higher-order (23rd) current harmonics, and to supply reactive power to the converter. A smoothing reactor is $(L-R)$ connected at the dc terminals of the inverter. At the receiving end, a three-phase bridge (6-pulse) cycloconverter is used to generate 20-Hz voltage. A filter $(L_f - R_f)$ is connected at the low-frequency side. At the grid the voltage side, ac filters are used to suppress odd current harmonics, and to supply reactive power to the cycloconverter.

A. Sending-End Control

The control structure for the sending-end inverter is shown in Fig. 2. The controller regulates the dc bus voltage V_{dc} by adjusting the voltage V at the inverter terminals. The cosine wave crossing method [10] is applied to determine the firing angle

$$\alpha_S = arccos\left(\frac{V^*}{V_P}\right) \qquad (1)$$

Where v_P is the peak value of the cosine wave. Note that $v^* < 0$ And $90^\circ < \propto_S < 180^\circ$ (using common notation), since the converter is in the inverter mode of operation [11].V and V_S(line-to-neutral, rms) are related by [15].

$$\mathrm{V} = \frac{6\sqrt{6}}{n_s} V_S \cos(\propto_S) \qquad (2)$$

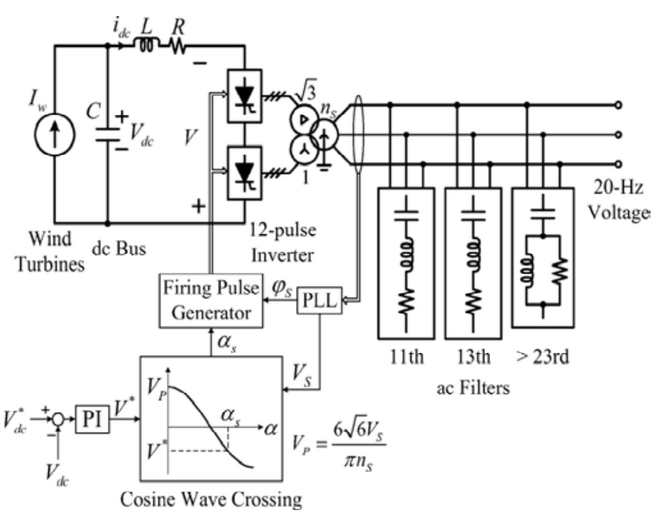

Fig. 2. Sending-end inverter control.

A phase-locked loop (PLL) provides the angular position of the ac-side voltage, which is necessary for generating the firing pulses of the thyristors. It also outputs the rms value of the A phase-locked loop (PLL) provides the angular position of the ac-side voltage.

B. Receiving-End Control

The structure of the cycloconverter controller at the receiving end is illustrated in Fig. 3. The control objective is to provide a constant 20-Hz voltage1 of a given rms valueV_{cyc}^* (line-to- neutral).The firing angles of the phase- positive and negative converters (denoted as "*aP*" and "*aN*" in Fig. 3) are $\propto_a P$and $\propto_a N$ respectively. For the positive converter, the average voltage at the 20-Hz terminals is given by [15].

$$V_{aP} = \frac{3\sqrt{6}V_G}{\pi n_R}\cos(\alpha_a P) \qquad (3)$$

where V_G is the rms value of the line-to-neutral voltage at the grid side, and $n_R$is the turns ratio of the transformers. The condition $\propto_a p + \propto_a N = \pi$ ensures that average voltages with the same polarity are generated from the positive and negative converter at the 20-Hz terminals [13].

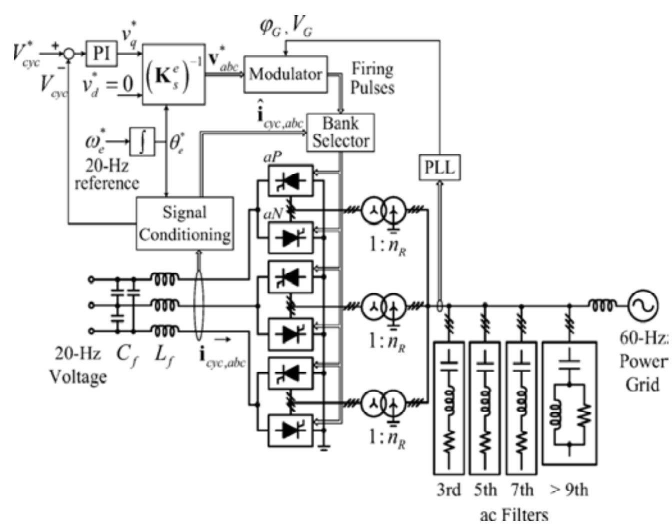

Fig.3. Receiving-end cycloconverter control. (The reference frame transformation matrixK_s^e is defined in [16], and transforms variables from the stationary to the synchronous reference frame.)

The firing pulsesS_{aP} and S_{aN} are not simultaneously applied to both converters, in order to obtain a noncirculating current mode of operation. This functionality is embedded in the "Bank Selector" block of Fig. 3, which operates based on the filtered current$i_{cyc,abc}$. Note (for later use) that the maximum line-to-neutral rms value of the 20-Hz cycloconverter voltage and that a voltage ratio is defined

$$V_{cyc}^{max} = \frac{3\sqrt{3}V_G}{\pi n_R} \quad (4) \quad \& \quad r = \frac{V_{cyc}}{V_{cyc}^{max}} \quad (5)$$

In practice, the theoretical maximum value $r = 1$ cannot be achieved, due to the leakage inductance of the transformers, which was ignored in the analysis.

III. SYSTEM DESIGN

At the steady state, the average value of the dc current I_{dc} is equal to I_w, so the power delivered from the wind turbines is $P_w = V_{dc}I_w$ (6)

For the 12-pulse converter, the rms value of the current at the transmission side is [15]

$$I = \frac{2\sqrt{6}}{\pi}\frac{I_w}{n_S} \quad (7)$$

Hence, (7) can be written as

$$I = MP_w \quad (8) \quad \text{Where} \quad M = \frac{2\sqrt{6}}{\pi n_S V_{dc}} \quad (9)$$

$$P_S = P_w = 3V_sI\cos(\propto_S - 180°) = -3V_SI\cos(\propto_S) > 0 \quad (10)$$

Substitution of (8) into (10) yields

$$\cos(\propto_S) = -\frac{1}{3MV_S} \quad (11) \quad \& \quad \sin(\propto_S) = \sqrt{1-\frac{1}{9M^2V_S^2}} \quad (12)$$

The reactive power generated from the 12-pulse inverter is

$$Q_S = 3V_SI\sin(\propto_S - 180°) = -3V_SI\sin(\propto_S) \quad (13)$$

From (10)–(13), it follows that

$$Q_S = P_S\tan(\propto_S) = -P_S\sqrt{9M^2V_S^2 - 1} \quad (14)$$

Given a power rating of a wind power plant , the maximum reactive power that is absorbed by the 12-pulse inverter can be estimated according to (14), which yields

$$Q_{rated} = P_{rated}\sqrt{3M^2V_0^2 - 1} \quad (15)$$

where is the nominal transmission voltage level (line-to-linerms).Here, it is assumed that the sending-end ac filters supply the rated reactive power to the inverter. Therefore

$$C_{eq} = \frac{Q_{rated}}{w_eV_O^2} \quad (16)$$

where $\omega_e = 2\pi 20$ rad/s. In addition, the apparent power rating of the transformer at the sending end S_{ts} should satisfy

$$S_{tS} > \sqrt{P_{rated}^2 + Q_{rated}^2} = \sqrt{3}P_{rated}MV_o \quad (17)$$

Since the ac filters are designed to supply all reactive power to the 12-pulse inverter at the sending end, the reactive power injected into the 20-Hz side of the cycloconverter can be estimated by using

$$Q_{cyc}^{20} \approx Im\{Y'\}V_o^2 + w_e3C_fV_o^2 - 3I_{rated}^2Im\{Z'\} - 3I_{rated}^2w_eL_f \quad (18)$$

The active power injected into the cycloconverter from the 20-Hz side can be estimated by using

$$P_{cyc}^{20} \approx P_{rated} - Re\{Y'\}V_o^2 - 3I_{rated}^2Re\{Z'\} \quad (19)$$

The 60-Hz side power factor PF^{60} at the transformers' gridside terminals can be obtained using the 20-Hz power factor and the voltage ratio based on the analysis and calculations of ([30, p. 358]). Then, the apparent power rating of each of the three receiving-end transformers S_{tR} should satisfy

$$S_{tR} > \frac{P_{cyc}^{20}}{(3)(PF^{60})} \quad (20)$$

Also, it is assumed that the grid-side ac filters are designed to supply the rated amount of reactive power to the cycloconverter. At the sending end, the 12-pulse inverter produces harmonics of order$m = 12k \pm 1, k = 1,2,.,.,.$, and can be represented as a source of harmonic currents. These current harmonics are filtered by two single-tuned filters for the 11th and 13th harmonic, and one damped filter for higher-order harmonics (≥ 23rd). Generally, the filter design is dependent on the reactive power supplied at fundamental frequency (also known as the filter size) and the required quality factor (QF) [18].The total reactive power requirement of these filters can be estimated based on (15). At the receiving end, there are two groups of filters, namely, the ac filters at the 60-Hz side and the *LC* filter at the 20-Hz side. At the 60-Hz side, if the cycloconverter generates exactly one-third of the grid frequency, and it can be shown [30, p. 360] that the line current has only odd harmonic components (3rd, 5th, 7th, etc). Subharmonic and interharmonic components are not generated. Here, three single-tuned filters and one damped filter are used to prevent these harmonic currents from being injected into the 60-Hz power grid. These filters are designed with a procedure similar to that for the ac filters at the sending end.

At the 20-Hz side, the line-to-neutral voltage At the 20-Hz side, the line-to-neutral voltage has harmonics of order 3, 5, 7,… without subharmonic and inter harmonic components. However, the harmonic components of order equal to integer multiples of three are absent in the line-to-line voltage. Therefore, as seen from the 20-Hz side, the cycloconverter acts as a source of harmonic voltages of orders $n = 6k \pm 1, k = 1,2,$ ..... The design of the *LC* filter has two objectives:

1) to decrease the amplitudes of the voltage harmonics generated by the cycloconverter;
2) to increase the equivalent harmonic impedance magnitudes seen from the receiving end, indicated by$Z_R(w_n)$

To control the output Voltage we have two Techniques

1. PI Controller (Proportional Integral Controller)
2. Fuzzy Logic Controller

PI (Proportional Integral Controller)

- In Pi the output Voltage Can't be controlled.
- If once we given the input we cant change .
- If we give the input then output is produced . But the output is decided by PI only .
- That's why we can't get the output as per our requirement .

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- We can't change the input value during the Simulation Running period Because the PI is Between input and Output .

Fuzzy Logic Controller

- FLC (Fuzzy Logic Controller) is nothing but set of rules .
- Fuzzy Logic Controller build by using the GUI(Graphical User Interface) tool and that is provided by the Fuzzy tool Box , It is used to build the system Graphically.
- There are Five primary GUI tools for building , editing and observing the Fuzzy in Fuzzy tool Box.

IV. SIMULATION RESULTS

To demonstrate the validity of the proposed LFAC system, simulations have been carried out using Matlab/Simulink and the Piecewise Linear Electrical Circuit Simulation (PLECS) toolbox [14]. The wind power plant is rated at 180 MW, toolbox and the transmission distance is 160 km. The system parameters are listed in Table I. The parameters of the PI controllers in Figs. 2 and 3 are listed in Table II. The transmission power cable is modeled by cascading 20 identical sections.

Fig. 4 shows the steady-state line-to-line voltage and current waveforms at the sending end, the receiving end, the 20-Hz side of the cycloconverter, and the 60-Hz power grid side under rated power conditions. The 20-Hz voltage generated from the cycloconverter has significant harmonic distortion (THD is 14.8%). Due to the *LC* filter, the voltages at the receiving and sending ends have reduced THD values (3.9% and 2.2%, respectively).

TABLE I
LFAC SYSTEM SIMULATION PARAMETERS

Sending End

dc Bus Capacitor		$C = 1000\ \mu$F	
Smoothing Inductor		$L = 0.1$ H, $R = 1$ mΩ	
20-Hz Phase-shift Transformer			
Rated Power	214 MVA	Voltage	132/13.2 kV
Winding Resistance	0.001 p.u.	Leakage Reactance	0.05 p.u.
Magnetizing Resistance	1000 p.u.	Magnetizing Reactance	200 p.u.
ac Filters (115 MVAr, 132 kV, 20 Hz)			
	R (Ω)	L (mH)	C (μF)
11 th	0.41	29.7	17.6
13 th	0.35	21.3	17.6
> 23 rd	19.7	6.8	17.6

Transmission Power Cable (132 kV)

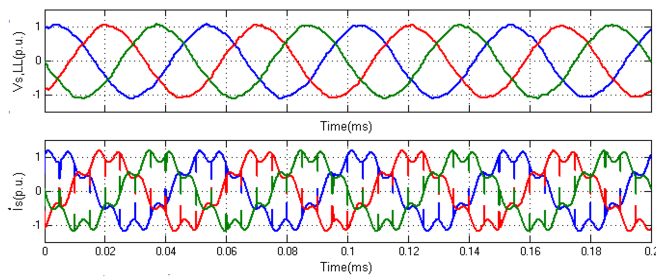
Resistance	17.6 mΩ/km	Inductance	0.35 mH/km
Capacitance	0.25 μF/km	Rated Current	825 A

Receiving End

LC Filter		$L_f = 63$ mH, $C_f = 8.7\ \mu$F	
Transformers			
Rated Power	100 MVA	Voltage	132/88 kV
Winding Resistance	0.001 p.u.	Leakage Reactance	0.05 p.u.
Magnetizing Resistance	1000 p.u.	Magnetizing Reactance	200 p.u.
ac Filters (200 MVAr, 132 kV, 60 Hz)			
	R (Ω)	L (mH)	C (μF)
3 rd	1.16	102.7	7.6
5 th	0.70	37.0	7.6
7 th	0.50	18.9	7.6
> 9 th	38.7	11.4	7.6

TABLE II
PARAMETERS OF PI CONTROLLERS WITH H(s) = K(1+((1)/τ_s)

	Sending end	Receiving end
K	1	0.125
τ	0.1	0.05



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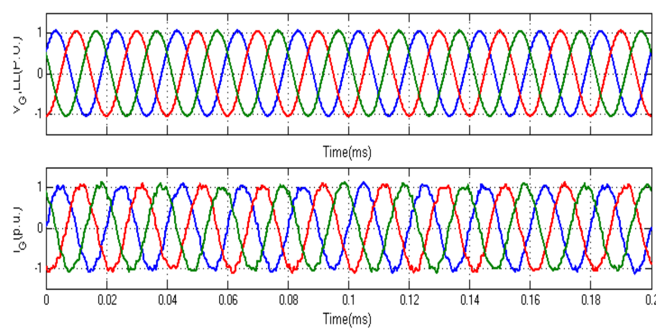

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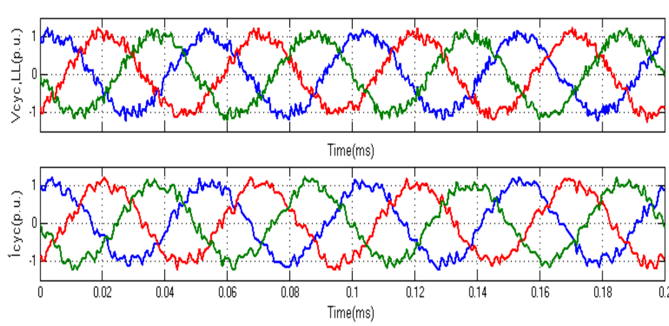

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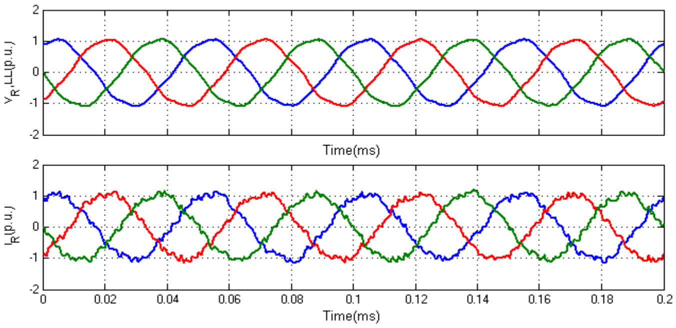


(d)

Fig. 4. Simulated voltage and current waveforms with PI controller. (Please refer to Fig. 1 for voltage and current monitoring positions.) (a) Sending end. (b) Receiving end. (c) Cycloconverter 20-Hz side. (d) 60-Hz power grid side.

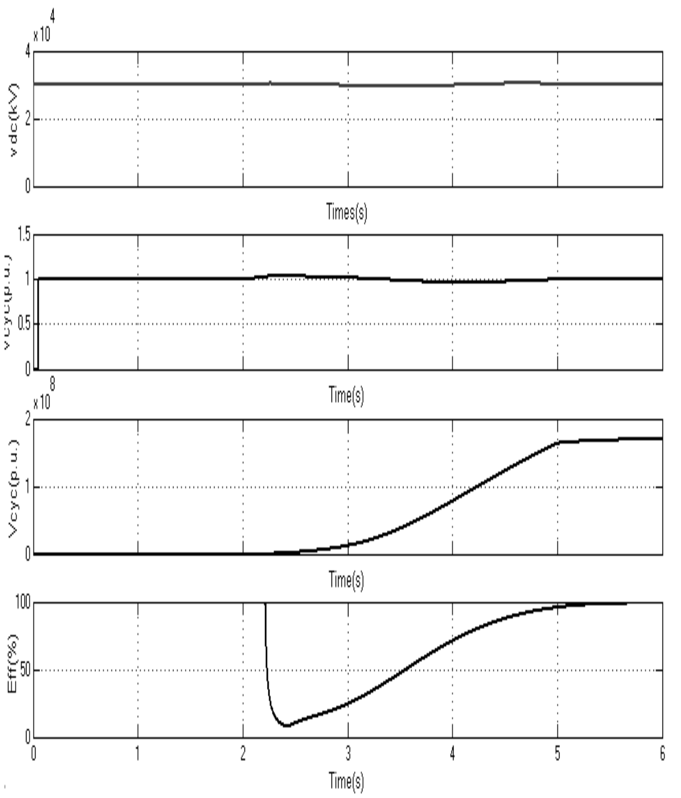
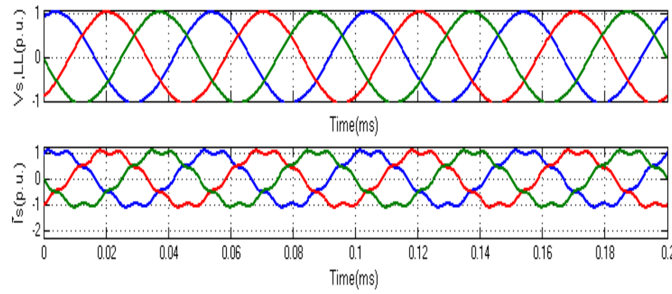


Fig. 5. Transient waveforms during a wind power ramp event with PI controller.

Fig.5 depicts the results of a transient simulation where the power from the wind turbines ramps from 0 to 180 MW, at a rate of 60 MW/s (perhaps unrealistically fast, but chosen to demonstrate that the system is stable even for this large transient). Shown are the transient responses of the dc bus voltage at the sending end, the magnitude of the fundamental component of the 20-Hz voltage generated by the cycloconverter, the active power injected into the 60-Hz power grid, and the transmission efficiency (which reaches a value of 96% at rated power).

For extension of this project we are using fuzzy. The parameters are same as PI controller. Fig.(6) and Fig.(7) show the results for extension of this project. In this we are improving the efficiency 2%. By using fuzzy we will get 98% efficiency and also we can reduce the ripples.



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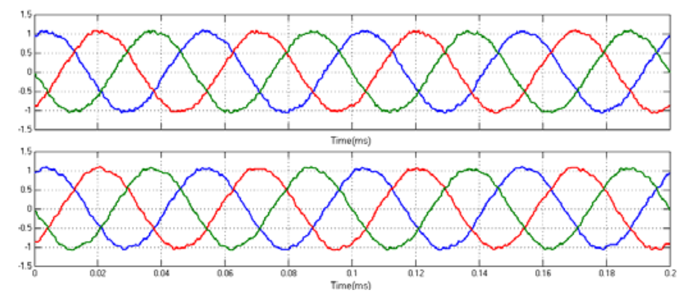

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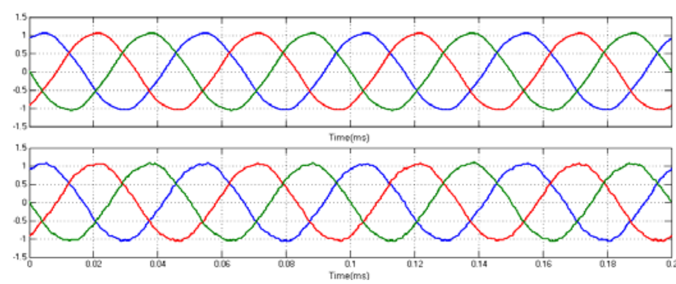

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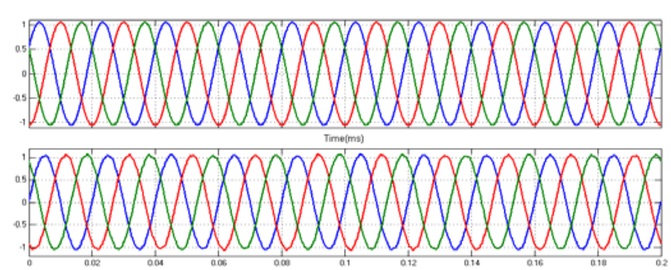

(d)

Fig. 6. Simulated voltage and current waveforms with fuzzy controller. (Please refer to Fig. 1 for voltage and current monitoring positions.) (a) Sending end. (b) Receiving end. (c) Cycloconverter 20-Hz side. (d) 60-Hz power grid side.

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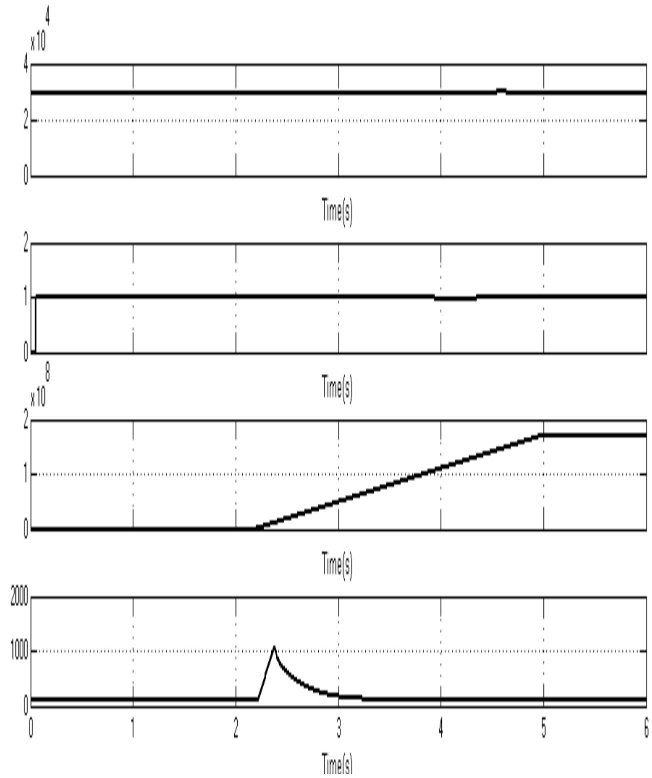

Fig. 7. Transient waveforms during a wind power ramp event with Fuzzy controller

V. CONCLUSION

High voltage ac transmission for offshore wind power with low-frequency has been proposed. A method to design the system's components and control strategies has been discussed. The use of a low frequency can improve the transmission capability of submarine power cables due to lower cable charging current. It might be easier to establish an interconnected low-frequency ac network to transmit bulk power from multiple plants. The proposed LFAC system appears to be a feasible solution for the integration of offshore wind power plants over long distances, and it might be a suitable alternative over HVDC systems in certain cases.

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An Energy Storage Based Facts Device to Damp Tie Line Oscillations and Voltage Profile Improvement under Transient State Using Fuzzy Logic Controller

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***Abstract*-Large interconnected power systems often suffer from weakly damped swings between synchronous generators and subsystems. This paper proposes an Superconducting Magnetic Energy Storage System(SMES) based Unified Power Flow Controller(UPFC) using Fuzzy logic controller to damp tie line oscillations and improve the voltage profile under transient condition. This novel method provides active and reactive power controllability through the line. Thus the SMES based UPFC is effective in damping inter area oscillations, and the performance of device is compared with fuzzy controller against PI controller. The effectiveness of the proposed approach to modeling and simulation is implemented in Simulink environment of MATLAB.**

Keywords-PWM based Voltage Source Converter, UPFC, SMES, Fuzzy logic controller, Power Oscillation Damping.

I. Introduction

Due to increased power demand modern power systems are mostly interconnected systems. The main advantages of interconnected power systems are improving reliability and pooling reserves, reduced investment in generating capacity, economic exchange and so on. But due to this interconnection there is chance of occurrence of electro mechanical oscillations [4], which cause severe problems like generators damage, the reduction of power transfer ability of transmission lines, losses on line increases, wear and tear on the network components increases and so on. Due to the swinging of synchronous generators against each other electromechanical oscillations occur [4]. These kind of oscillations are produced when the rotor of the machines behaves as rigid bodies and oscillation energy will be exchange between the machines through transmission lines. In local mode [4,5] one generator swings against the rest of the system at 1.0 to 2.0Hz, the impact of the oscillation is localized to the generator and the line connecting it to the grid. Inter area mode of oscillations is observed over a large part of the Network, it involves two coherent groups of generators swinging against each other at 1Hz or less. This phenomenon involves many parts of the system with highly non linear dynamic behavior. Traditionally Power system stabilizers are used to damp such electromechanical oscillations. But they are effective for local modes only whereas in large power systems they will not provide enough damping for interarea modes. So, more efficient substitutes are needed other than Power system stabilizers.

To increase controllability and optimize the utilization of the existing power system capacities a reliable and high speed power electronic device based FACTS (Flexible AC Transmission System) technology is introduced. The latest generation of FACTS controllers is based on the concept of Solid State Synchronous Voltage Sources (SVS) introduced by L.Guygyi. The SVS behaves as an ideal synchronous machine, i.e., it generates three-phase balanced sinusoidal voltages of controllable amplitude and phase angle with fundamental frequency. The SVS can be implemented by the use of the voltage source converters (VSC). In order to damp this inter area mode oscillations FACTS controllers [1] like Static synchronous compensator (STATCOM)[6], Static series synchronous compensator (SSSC)[5], Unified power flow controllers(UPFC)[1] etc. are used. The UPFC is one of the most versatile device, which is a combination of STATCOM and SSSC, DC link capacitor acts as common between both shunt and series converters.

So in this paper a new control technique using unified power flow controllers (UPFC) with superconducting magnetic energy storage system (SMES) [2,3,7,9] using fuzzy logic controller in order to damp the interarea oscillation under transient condition in an effective manner is introduced. SMES has the advantages of high energy density, fast response, high efficiency, minimum energy loss during the conversion etc comparing with other power supplies.

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II. UNIFIED POWER FLOW CONTROLLER (UPFC)

The UPFC is superior to the FACTS devices in terms of performance. It contains two voltage source converters connected "back to back" using insulated gate bipolar transistor (IGBT) with a common DC link. One connected in parallel with the transmission line through shunt transformer and another connected in series with the transmission line through series transformer. The real power demanded by the series converter is supplied by shunt converter through DC link capacitor. The series converter injects the AC voltage with controllable magnitude and phase angle to the transmission line.

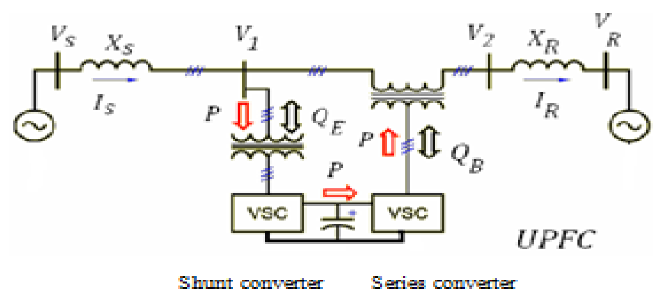

Figure 1. Schematic of UPFC

The active and reactive power exchange with the AC system takes place when the transmission line current flows through series converter. Between the two converters there will be no exchange of reactive power; only real power transfer takes place. Thus independently shunt converter provides voltage control and series converter provides both active and reactive power flow control. Different methods to control series voltage magnitude, angle and shunt current magnitude are present [1,5].

A. Shunt Branch of UPFC:

In the shunt branch of UPFC, the converter produces a set of controllable three-phase output voltages from the DC voltage source provided by the charged capacitor with the frequency of the AC power system. The three phases output voltage is in phase with and coupled to AC system voltage through a small tie line reactance (0.1-0.15 p.u.). That is, if the AC system voltage is less than the amplitude of the converter output voltage due to increased loads of system then current will increase and voltage level decreases, in such cases the currents will flow from converter to the AC system through tie line and the converter generates reactive power (capacitive) to the system. Similarly if the AC system voltage is higher than the converter output voltage then the current flows from AC system to the converter and the converter absorbs reactive power (inductive) from the system. If the AC system voltage is equal to the amplitude of converter output voltage then there will be no reactive power exchange.

The reactive current drawn by the synchronous compensator is

$$I = \frac{1-\frac{V_C}{V_L}}{X} V_L \qquad (1)$$

The Reactive power exchanged can be expressed as

$$Q = \frac{1-\frac{V_C}{V_L}}{X} V_L^2 \qquad (2)$$

Where V_L = Transmission line voltage,

V_C = Converter output voltage

X = Reactance plus Transformer leakage reactance plus System short circuit reactance

B. Series Branch of UPFC:

In the series branch of UPFC, The series converter is a controlled voltage source connected in series with the transmission line to control current. One side of converter is connected to AC system and the other side is connected to capacitor. If any dynamic change in the system occurs, for controlling active and reactive powers the series branch operates. Series converter provides the main function of the UPFC by injecting an ac voltage with controllable magnitude and phase angle at the power frequency, inserted with line via an insertion transformer. This injected voltage can be considered essentially as a synchronous ac voltage source. The transmission line current flows through this voltage source resulting in real and reactive power exchange between it and the ac system. The real power exchanged at the ac terminal (i.e. at the terminal of the insertion transformer) is converted by the inverter into dc power which appears at the dc link as positive or negative real power demand. The reactive power exchanged at the ac terminal is generated internally by the inverter.

Under any sudden disturbance condition, the energy stored in DC capacitor is not capable of damping so to overcome this we go for substantial power supplies such as SMES.

III. SUPERCONDUCTING MAGNETIC ENERGY STORAGE SYSTEM (SMES)

Superconducting Magnetic Energy Storage unit stores energy in the form of magnetic field which is generated by dc current flowing through the superconducting coil. Although SMES device itself is highly efficient and has no moving parts, it must be cryogenically cooled to maintain the superconducting properties of the wire, thus incurs energy and maintenance costs. SMES are used to improve power quality because they provide short bursts of energy in less than a second.

A typical SMES system includes three parts i.e, superconducting coil, power conditioning system and cryogenically cooled refrigerator. Once the superconducting coil is charged, it stores in the form of magnetic field. This

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stored energy is released back to the power conditioning system uses inverter/rectifier, by discharging the coil. An electronic interface known as chopper is needed between the energy source and VSI. The energy source compensates the capacitor charge through chopper needed by VSI. The chopper is a two-quadrant n-phase DC-DC converter as shown in figure2.

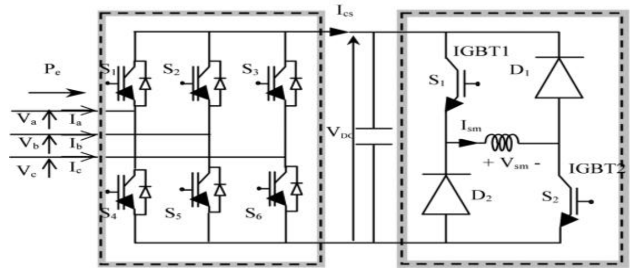

Figure 2. The Configuration of SMES unit with Chopper

The chopper operates in three modes of charge, discharge and storage in the SMES device. In the charging mode of superconducting coil, the chopper is operated in step down configuration. Here the IGBT "S_1" is operated with the duty cycle D while the IGBT "S_2" is kept ON at all times. The relationship between the dc bus voltage and coil voltage can be written as

$$V_{smes} = D * V_{DC} \qquad (3)$$

The operating mode of chopper is changed to standby mode, once charging of superconducting coil is completed. In this case the IGBT "S_1" is kept OFF all the time while the IGBT "S_2" is kept ON constantly. In the discharge mode the chopper is operated in step up configuration. Here the IGBT "S_2" is operated with duty cycle D while the IGBT "S_1" is kept OFF at all times. The relationship between dc bus voltage and coil voltage can be written as

$$-V_{smes} = (1-D) * V_{DC} \qquad (4)$$

The relationship between dc bus voltage and output voltage of inverter is given as

$$V_{DC} = K_a V_{inv} \qquad (5)$$

Where $K_a = K * a$ (6)

K=Pulse number, a=Ratio of coupling transformer.

IV. UNIFIED POWER FLOW CONTROLLER WITH SMES

The UPFC is a combination of STATCOM and SSSC. The dq components of shunt current are I_{d_1} and I_{q_1} respectively. Whereas I_{d_2} and I_{q_2} are dq components of series current. The sending end and receiving end voltages are $V_1\underline{|\theta_1}$ and $V_2\underline{|\theta_2}$. The UPFC is controlled by varying output voltage magnitudes K_1 and K_2 of the shunt and series converter and phase angles α_1 and α_2 of the series converter. The SMES is connected to the DC capacitor through a bidirectional dc-dc converter shown in figure 3.

The voltage across dc-link capacitor and SMES voltage are related through duty cycle ratio D as follows

$$V_{dc} = \left\{ \frac{D}{1-D} \right\} V_{dcsmes} \qquad (7)$$

-

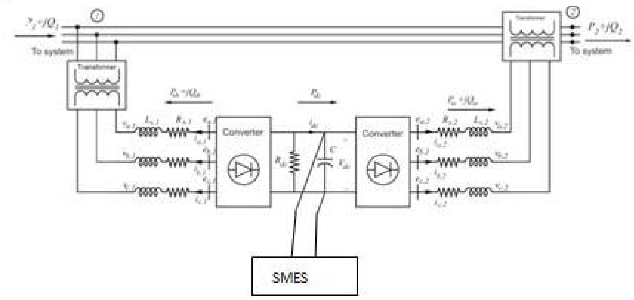

Figure 3. UPFC with SMES diagram

Based on Duty cycle the charging and discharging of SMES takes place. For example, if D<0.5 the SMES average voltage is positive, consequently chopper will be in charging mode and absorbs the energy and current through SMES is increased. When D>0.5 chopper operates in discharging mode and injects energy into the power system. When D=0.5 the chopper will be in standby mode and the average voltage across SMES coil will be zero, so there will be no exchange of energy with the power system. In the internal shunt control scheme the voltage across capacitor is compared with constant value and the error is given as input to PI controller which produces reference value of active current product with current vector of sending end voltage. This current vector is compared with receiving end current and according to the error the PWM generator generates pulses accordingly shunt converter produces output voltage based on converter output voltage the exchange of reactive and real power, storage across capacitor takes place. But the Shunt converter in maintaining required voltage across capacitor for series converter is not effective by using PI controller.

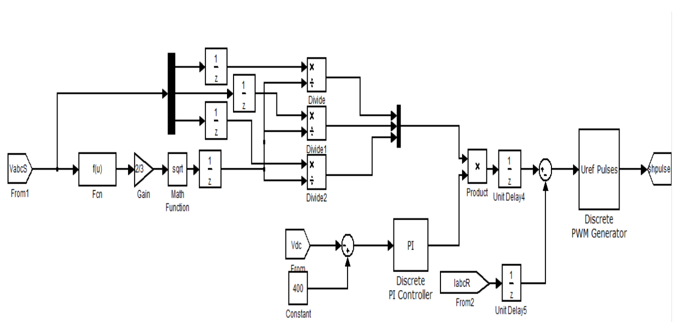

Figure4. Internal Shunt Control of UPFC with SMES using PI control

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V. DESIGN OF FUZZY LOGIC CONTROLLER

Fuzzy logic controllers are largely becoming an alternative for classical controllers. Fuzzy logic controllers are nothing but a Fuzzy code designed to control something. Fuzzy logic technology enables the use of engineering experience and experimental results in designing an embedded system. Advantages of Fuzzy logic controllers are very robust, can be easily modified; can use multiple inputs and multiple outputs sources, very quick and cheaper to implement. The Fuzzy controller includes three steps i.e. Fuzzification, Fuzzy Inference System and Defuzzification as shown in figure 5.

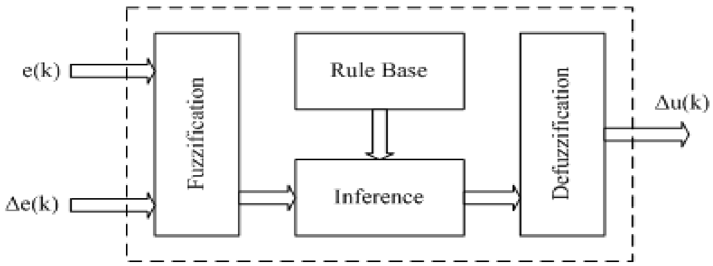


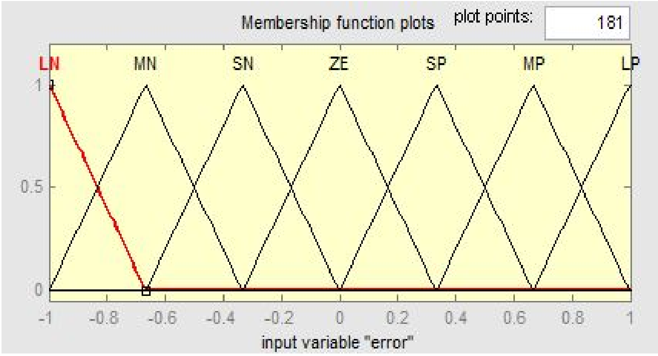
Figure 5. Fuzzy logic Control scheme

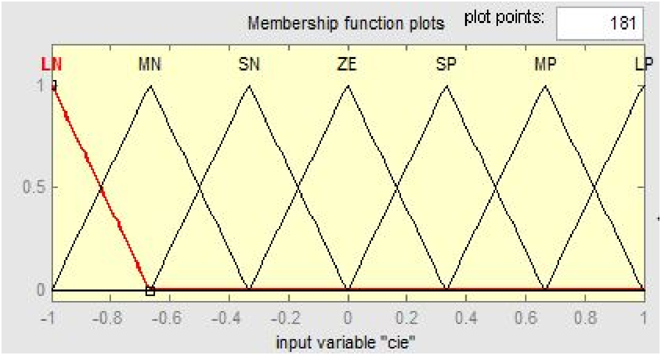
In this case the error and change in error are inputs to fuzzy quantities based on this membership functions are determined. Here we have seven membership functions for each input so that 49 rules are formed. Fuzzy inference system is a decision making system, it uses "if-then" rules along with "OR or AND" for making necessary decision. In the defuzzification block the fuzzy quantities are converted to Crisp quantities. The Rules which are used in Fuzzy inference system are as shown below

TABLE 1. Fuzzy Rule Table

CIE / E	**NL**	**NM**	**NS**	**ZE**	**PS**	**PM**	**PL**
NL	PL	PL	PL	PM	PM	PS	ZE
NM	PL	PM	PM	PM	PS	ZE	NS
NS	PL	PM	PS	PS	ZE	NS	NM
ZE	PM	PM	PS	ZE	NS	NM	NM
PS	PM	PS	ZE	NS	NS	NM	NL
PM	PS	ZE	NS	NM	NM	NM	NL
PL	ZE	NS	NM	NM	NL	NL	NL

The various membership functions used in fuzzy are triangle, trapezoidal, Gaussian and sigmoid. In this paper triangular membership function is used, advantage of using triangular function is it produces fast response and complexity in calculations reduced.





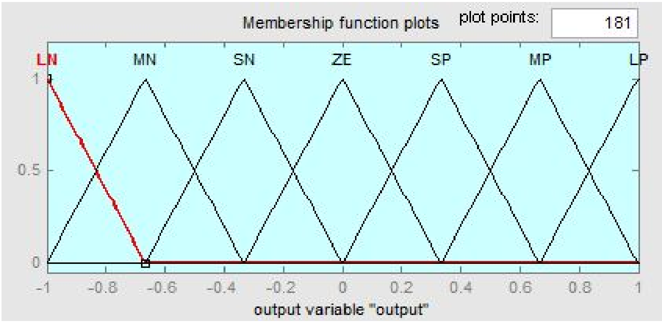


Figure 6. Input and Output membership functions of FLC

In this case the inference engine used is mamdani. The input and output memberships used in this work is shown in fig 6. Here all the membership functions are uniformly distributed in the range [-1,1]. In mamdani inference system the rules are simulated and gives the output in fuzzy. Then defuzzification is done in order to convert the fuzzy values into the real scalar values using centroid method.

Fig.7 shows the block diagram of proposed control scheme. The PI controller was replaced by Fuzzy logiccontroller. The error in voltage across capacitor compared to constant value is taken as input to fuzzy logic controller.

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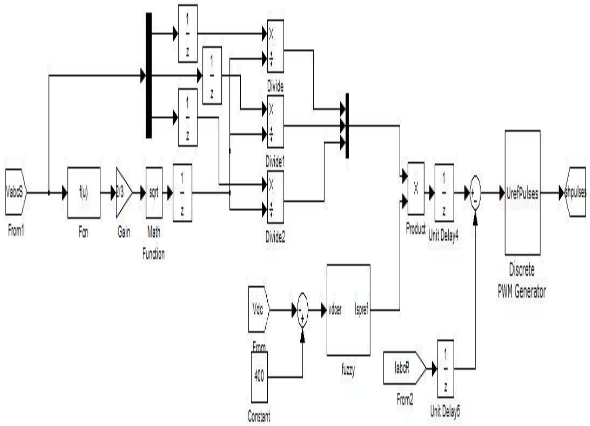

Figure7. Internal Shunt Control of UPFC with SMES using Fuzzy controller

VI. SIMULINK Model of SMES Based UPFC System

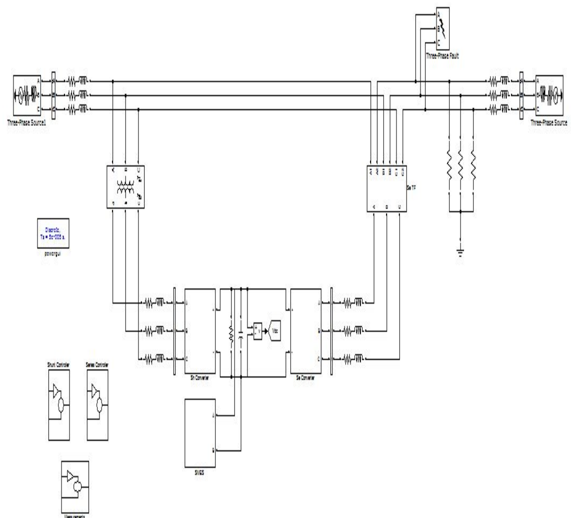

Figure 8. Simulink model of UPFC with SMES

The Simulink model consists of two three phase sources connected by a tie line with a three phase fault, small resistive load and UPFC device along with SMES. UPFC device is operated by its internal shunt and series control circuit whereas SMES is operated by chopper control circuit.

A three phase fault is created in line for t=0.0167sec to 0.41sec. The variation of active power, reactive power, voltage across capacitor, voltage and currents at both ends are observed for both PI and Fuzzy controllers.

VII. RESULTS AND COMPARISON

For the system a three phase fault is created on bus at t=0.0167 sec to 0.41 sec. The location and duration of fault were chosen to provide a significant disturbance to the interior of the power system and the comparison shows how inter area oscillations are damped and how dc link provides compensation.

A. Voltage and Current Waveforms at the Sending end and Receiving end:

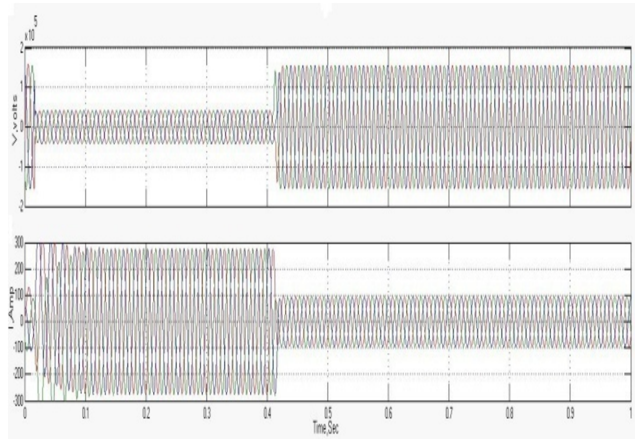

Figure 9. Voltage and Current Waveforms at Sending end

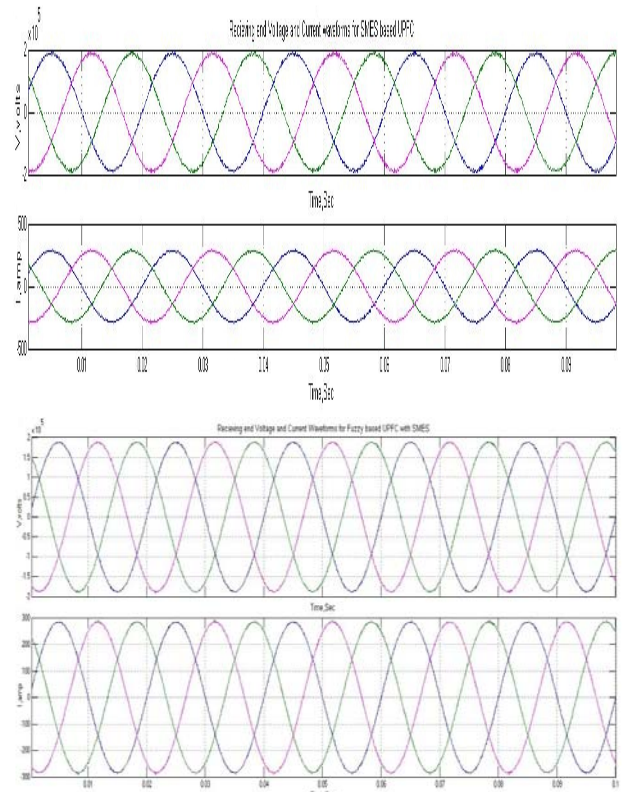

Figure 10. Receiving end voltage and current waveforms for PI and Fuzzy controller

From both waveforms it is clear that at the sending end during the fault the voltage drops and current increases. At the receiving end the ripples in voltage and current are almost reduced by using fuzzy controller compared to PI. Thus using fuzzy the Voltage profile is improved.

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B. Active power Comparison of UPFC with SMES for both PI and FUZZY controllers:

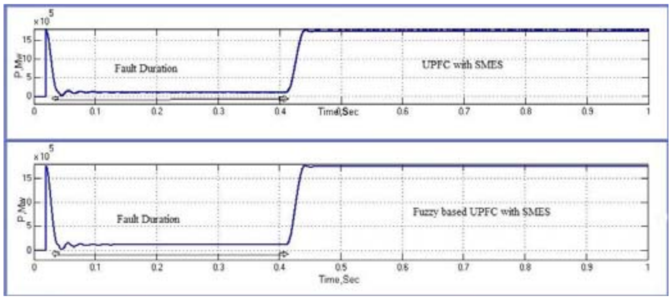

Figure 11. Active power using PI and Fuzzy controller

It is clear from simulation results that before the settling of active power the power oscillations are high when we use UPFC with SMES using PI controller. Also the oscillations are damped quickly using Fuzzy controller.

C. Reactive Power comparison of UPFC with SMES for both PI and FUZZY controllers:

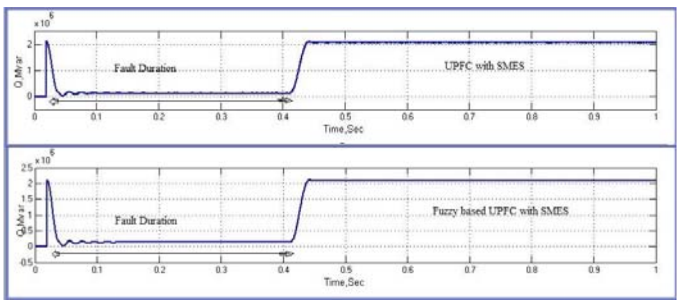

Figure 12. Reactive Power using PI and Fuzzy controller

It is clear from simulation results that before the settling of reactive power the power oscillations are high when we use UPFC with SMES using PI controller. Also the oscillations are damped quickly using Fuzzy controller.

D. DC link voltage comparison of UPFC with SMES for both PI and Fuzzy controllers:

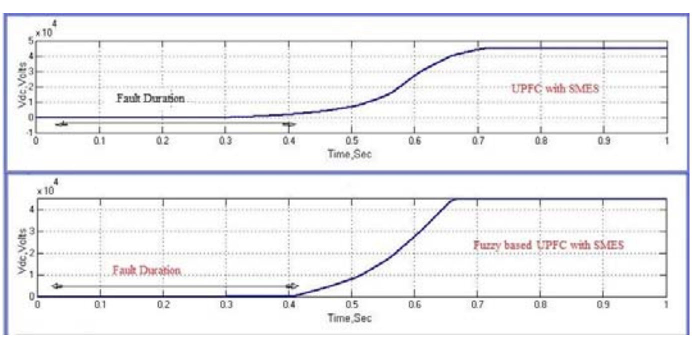

Figure 13. DC link Voltage using PI and Fuzzy controller

It is clear from the simulation results that under transient duration the SMES tries to maintain required voltage across capacitor within small duration and it is also observed that the settling time for the test system by using fuzzy controller is minimum compared to PI controller.

CONCLUSION

The control strategy to damp the tie line oscillations by maintaining required active and reactive power through the line using UPFC-SMES is done. The damping of proposed system using fuzzy compared to conventional system using PI is improved. The deviation of voltages, real and reactive power are experimentally done using MATLAB-SIMULINK.. It is clear from the results that the UPFC with SMES using fuzzy is very effective in maintaining active and reactive power through the line by maintaining voltage stability across capacitor reducing harmonic content and fluctuations.

Also, with the use of hybrid controllers such as neuro-fuzzy or neuro-fuzzy genetic systems can be modeled to improve Stability of a Power System.

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Simulation of Collision Resistant Secure Sum Protocol

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***Abstract*— secure multi-party computation is widely studied area in computer science. It is touching all most every aspect of human life. This paper demonstrates theoretical and experimental results of one of the secure multi-party computation protocols proposed by Shukla et al. implemented using visual C++. Data outflow probability is computed by changing parameters. At the end, time and space complexity is calculated using theoretical and experimental results.**

***Keywords-* Security, Confidentiality, Trust, Privacy, Trusted third party (TTP) Secure Multi-Party Computations (SMC)**

I. INTRODUCTION

SMC works are mostly allocated to software agents, which can signify the participating parties, anonymizers and trusted third party. For example, Meeting scheduling problem where multiple employees will be the part of meeting but no one is interested in sharing his/her personal plan. Here, SMC techniques could be applied in such a way that meeting can be scheduled without any conflict and by hiding personal preferences.

The privacy preservation is a big challenge for data generated from various sources such as social networking sites, online transactions, weather forecast to name a few. Due to the socialization of the internet and cloud computing pica bytes of unstructured data is generated online with intrinsic values. The inflow of big data and the requirement to move this information throughout an organization has become a new target for hackers. This data is subject to privacy laws and should be protected. The proposed protocol is one step toward the security in case of above circumstances where data is coming from multiple participants and all the participants are concerned about individual privacy and confidentiality.

One technique to minimize privacy loss is to encode and hide [2] (identity) the association of the parties' sensitive data. Usually this is concerned as encryption and anonymization.

II. RELATED WORKS

Various researchers are working in the field of computation security, few people proposed solution for secure sum and other SMC operations. The authors have done extensive study on the previous work, out of that some of the most relevant work to the current research are discussed in this section.

Padwalkar et al. [3] presents a hybrid technique of secure multi-party computation, in this authors uses random number for data privacy, in the hybrid protocol participating parties and third party contribute for computation so it will be faster. This paper does not deal with communication security threat, when some parties are targeted purposefully and the case when third party becomes malicious.

Ayday et al. [5] presents a privacy preserving system for storing and processing genomic, clinical and environmental data by using privacy preserving integer comparison and homomorphic encryption. In this DNA sequence of patient is created by certified institution using the sample provided by the patient. The clinical and environmental data of the patient is collected from doctor, patient visits, or could be directly provided by the patient. (For ex. age weight, family history by patient whereas cholesterol level blood sugar level by his/her doctor's visits). All these information is considered as sensitive and need to be protected. Here, SMC is applied to preserve privacy of patients, against curious parties at storage and processing unit (SPU) and malicious parties at medical unit (MU). Genome is next big thing in medical science to identify disease risks. It could be possible by ensuring privacy of patients' sensitive data during the tests.

Sheikh et al. [7] explains the importance of modified ck-secure sum protocol over ck-secure sum protocol. In this protocol initiator changes its position in unidirectional ring, so that no neighbour remains together for more than one round. Here, data is divided into n segments (where 'n' is the number of party). On n^{th} round initiator announces the sum. For this protocol to work effectively minimum four parties are required. It doesn't deal with malicious parties and security threat.

Sheikh et al. [8] presents dk-secure sum protocol using ring arrangement. In this paper, parties exchange any 1 out of k segments, with any 1 party out of k, so all the parties have k-1 segment, plus 1 received from other party. In this protocol if two parties collaborate to get third parties data, then it may break the protocol (in case of three parties). This protocol works efficiently for four or more parties. In this paper authors assumed that communication channels are secure, it doesn't deal with insecure communication channels.

Sheikh et al. [9] presents a ck-secure sum protocol, in the proposed work authors divided data into fixed segments. The authors claim that, here probability of data leakage is zero. As this secure sum protocol uses changing neighbour mechanism, where neighbours are changed in each round with fixed protocol initiator. For this protocol to work accurately, minimum four parties are required. It doesn't deal with malicious behaviour of party and attacker during communications.

Clifton et al. [11] gives tools for privacy preserving data mining; in this random number mechanism is used to preserve privacy of individuals. In this, if two parties collaborate they can get the data of third party.

III. PROBLEM DEFINITION

The secure sum of parties' personal inputs is a good example of SMC which has attracted the attention of researchers from organization and academics to develop SMC protocol with minimum data leakage and higher confidentiality and security.

The secure sum protocol was initiated by Clifton et al. [11] in this authors used randomization technique for joint computation. In the proposed protocol participating parties were organized in a one-way ring. One party works as originator of the protocol through which computation begins by deciding a random number and adding it to its private data. The sum is forwarded to next party for further computation and so on.

Privacy preservation for secure multi-party computation problems have been achieved by other methods also [10, 6, 12] by mean of randomization and cryptography. But these solutions suffer from privacy loss in certain scenario. This paper presents simulation of protocol for privacy preservation to solve secure sum problem using randomization and anonymization.

A. *Formalization of Secure Sum Problem*

The secure sum problem consists of set of parties who wish to perform collaborative sum over parties' private input without revealing the data and identity of participants.

The SS problem is as follows:

1. A set of n parties P_1, P_2… P_n each party holds private data x_i where i € (1, 2… n).
2. A personal data set D = {x_1, x_2… x_n} is the set of all the parties' personal data.
3. A secure sum of parties personal data need to be computed without disclosing sensitive information.
4. The inter party constraints exists between the parties to share the data among the parties (if required).
5. The intra-party constraints of party P_i on x_i are the personal information of party P_i. It is known only to party P_i.
6. A reasonable solution S_{ln} is a representation of the secure sum of variable set.

IV. SIMULATION OF SECURE SUM PROTOCOL

This section presents a set of simulation analysis of the secure sum protocol. The privacy and security levels of the protocol has been analyzed using probabilistic analysis, here main emphasis is on the performance. Here the questions are: 1) how does this protocol work in case of colluding anonymizers? 2) How does this secure sum protocol perform in various settings, and how does this achieve the basic objective of privacy of sensitive information of individual participants?

This paper demonstrates the implementation of the randomization and anonymization based protocol for secure sum using time bound random function to generate the inputs. In order to answer first question, experiment has been performed ensuring no anonymizer get more than one packet from the same party so in this case probability of getting more than one packet of same party by malicious anonymizers is insignificant. To answer second question, the data is synthetically generated with varying parameters to test the protocol in different settings. Table 1 presents the parameters used for simulation. As shown in Fig. 1, for execution in batch these parameters are fetched from the text file which contents the values for these parameters.

In this paper experiment is performed in following settings:

Protocol initiator will decide number of party, packets per party and anonymizers are decided such that $m \geq (n \times (t_{pk} + t_{pk}))/m_x$ here '*n*' is the number of party, 't_{pk}' is the packets per party, and 'm_x' is the maximum limit of an anonymizer. All the experiments have been executed considering there is only one TTP.

A. *Simulation Setup*

The experiments have been executed using IntelCore2 duo T5450 processor clocked at 1.66 GHz and 2 GB of memory under windows 7 operating system. The secure sum protocol is evaluated using different set of parameters as shown in Table 1. For the test run parties input is generated using time based randomization function. All the result presented, are averaged from 500 test runs in batches. The tests runs in batches of 500 runs each, marking the average of the times noticed in the runs.

TABLE I. Table of Simulation Parameters

Parameter Name	Description	Default Value
n	Number of participating parties (minimum number of parties are 2)	10
m	Number of Anonymizers (minimum number of anonymizers are 4)	$m \geq (n \times (t_{pk} + t_{pk}))/m_x$
t_{pk}	Number of Packets per party (minimum 3)	3

B. *Distributed Randomized Secure Sum (DRSS)*

In the protocol [4] only one random number is added to the data so probability of breaking the protocol would be (1/n+1) but in this protocol it is reduced as different random numbers are added to each packet. The protocol can break only when all the random numbers and data packets are joined correctly. So the probability of breaking the protocol would be (1/n)*(1/n) which is insignificance and very less compare to

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JCRA [4]. This protocol was proposed by Shukla et al. [1] in this protocol at first the personal data is divided into packets, parties use dummy data to hide personal data contained in each packet. Hence, each party in this protocol must be able to divide the data into packets and generate dummy data using time bound random function. Than all the encoded packets are send to arbitrarily selected anonymizers. Anonymizers forward the packets to data pool and random number pool respectively. Finally it is the responsibility of TTP to compute the final secure sum using data and random number pool.

A.A.1 Simulation Steps

In the simulation *DRSS* protocol runs in the batches, the input data and random numbers are synthetically generated using random function, with varying parameters to test the protocol in different settings. After completion of the each run, outcome is stored for analysis & testing purpose. Once a batch run is complete the average of the time for each run is taken for comparative analysis.

V. RESULT AND ANALYSIS

A. Data Outflow probability

"Fig. 1" shows the experimental analysis, it illustrates that the data is divided by the party in the form of packets and distributed to different anonymizers. It is shown in the graph, if randomization factors are increased data leakage probability is reduced to negligible, it means the individual data privacy is increased.

$$\Pr(l,m) = \left(\frac{l}{m}\right)^{(2k)} \quad (1)$$

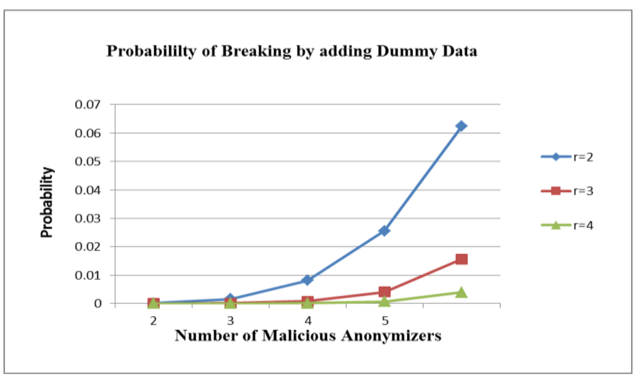

Figure 1 Data outflow probability by increasing randomization factor

B. Time Complexity

To find the impact of the proposed algorithm, a simulator was designed in Visual C++ and corresponding time complexities were recorded. The simulation result presents the proposed techniques although increases the time complexity but guarantees security in communication and computations. Graphs shown below illustrate the experimental results of execution time by increasing number of parties, packets and anonymizers respectively.

The time complexity is theoretically evaluated considering best, average and worst cases. The theoretical results are shown in "Fig. 2".

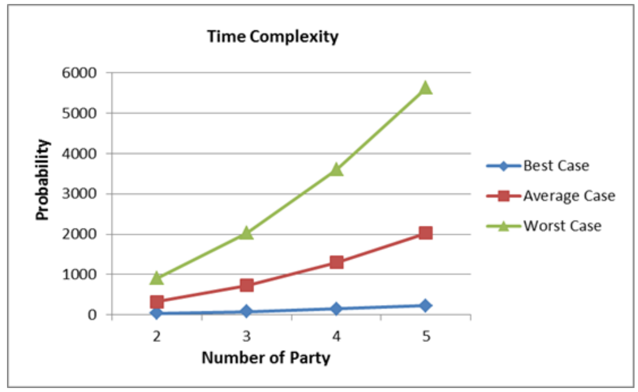

Figure 2 Result of theoretical time complexities

a) Case 1: Increasing Number of Party

"Fig. 3" shows the result, when the number of party increases, the overall computation time increases. It includes the time, for randomization of each party's data and packet distribution to different anonymizers. The test result shows that protocol is following the rule.

TABLE II. Test Result by increasing number of party

Number of Party	Average time taken in batch of 500, for tpk=3, m=5
2	761.3353293
3	770.3306122
4	777.428
5	785.788
6	795.916
7	797.916
8	806.67

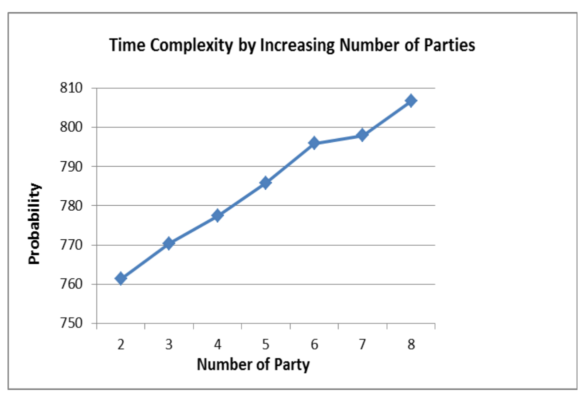

Figure 3. Time Complexity by increasing parties

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b) Case 2: Increasing Number of Packets and Party together

"Fig. 4" shows that increase in number of packets, increases time complexity, but as the number of packets increases privacy and security improves. As per the constraint no anonymizer get same parties packet more than once, to achieve this, it is required that the number of anonymizers should always be equal to or greater than the total number of packets per party. (Here m=5)

TABLE III. Test Result by increasing number of packets as well as parties

Number of Parties ⇨ Packets ⇩	3	4	5
2	787.877	816.298	865.072
3	798.3306122	837.692	867.356
4	837.064	840.082	873.272
5	867.974	927.8808081	1017.392

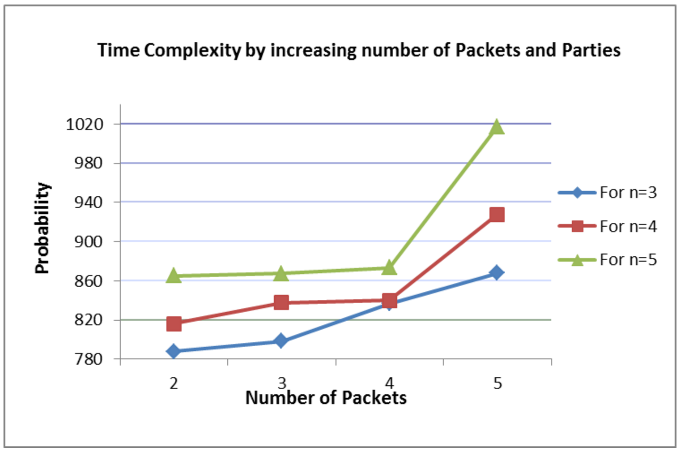

Figure 4. Time Complexity by increasing packets and parties together

c) Case 3: Increasing Number of Anonymizers

"Fig 5." shows that as the number of anonymizers increases, the execution time reduces so time complexity reduces. It reduces the overall cost of computations.

TABLE IV. Test Result by increasing number of anonymizers

Number of Anonymizers	For n=3, t_{pk}=3
5	798.3306122
6	773.32
7	763.802
8	758.782

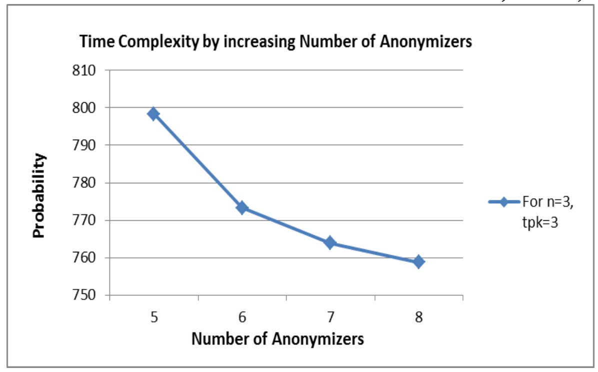

Figure. 5 Time Complexity by increasing Anonymizers

C. *Computation Complexity*

In the proposed protocol overall computation complexity at TTP is constant as in final computation TTP need to perform only one operation to generate the secure sum of multiple parties.

VI. CONCLUSIONS AND FUTURE WORKS

This paper shows the simulation result of a secure sum protocol. This result shows that, this is a noticeable improvement to already existing protocols. It provides better privacy, security against the hackers attack during communications. As compare to other protocols currently simulated protocol perform better, in case of semi-honest party for minimum of three parties. These results in high privacy, security and confidentiality which are highly important in medical, banking, and industries. In future the data distribution algorithm can be optimized to enhance the performance.

ACKNOWLEDGMENT

Authors wish to acknowledge Mr. Kapil Tiwari, EMC^2, Bangalore, India for his technical guidance and support.

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Battery Energy Storage System in DFIG Based Wind Energy Conversion System

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Abstract— This paper gives a new control strategy for a grid-connected doubly fed induction generator (DFIG)-based wind energy conversion system (WECS). Control strategies for the grid side and rotor side converters placed in the rotor circuit of the DFIG are presented along with the mathematical modeling of the employed configuration of WECS. The proposed topology includes a battery energy storage system (BESS) to reduce the power fluctuations on the grid due to the varying nature and unpredictability of wind. The detailed design, sizing, and modeling of the BESS are given for the grid power leveling. Existing control strategies like the maximum power point extraction of the wind turbine, unity power factor operation of the DFIG are also mentioned along with the proposed strategy of "grid power leveling." An analysis is made in terms of the active power sharing between the DFIG and the grid taking into account the power stored or discharged by the BESS, depending on the available wind energy. The proposed strategy is then simulated in MATLAB-SIMULINK and the developed model is used to predict the behavior.

Index Terms— **Doubly fed induction generator (DFIG), Battery energy storage system (BESS), grid power leveling, vector control, wind energy conversion system (WECS).**

I. INTRODUCTION

The electrical utility Industry continues to restructure, driven both by rapidly evolving regulatory environments and by market forces. The renewable energy has gained many advantages against the non renewable energy because of its non polluting& clean environment quality. wind energy conversion systems (WECS) have stood ahead of other renewable energy sources like solar energy, which still lags behind owing to high cost per kilowatt-hour (kWh) of electrical power generated. Overall, the contribution of these renewable energy systems to the power system has been increased rapidly from the last two decades [3]. Among all the available technologies for WECS, the doubly fed induction generator (DFIG) is most accepted because it combines the advantages of reduced converter ratings for power conversion and an efficient power capture due to the variable operation. The widely preferred topologies for the variable speed operation are the conventional asynchronous generators with rated power converters, the permanent magnet synchronous generators (PMSG's) with rated power converters, and the DFIG with partial rating power converters (slip power rating).

A DFIG-based WECS offers advantages of improved efficiency, reduced converter rating, reduced cost and losses, easy implementation of power factor correction, variable speed operation, and four quadrant control of active and reactive power control capabilities [6], [5]. Due to variable speed operation, total energy output is 20%–30% higher in case of DFIG-based WECS, so capacity utilization factor is improved and the cost per kWh energy is reduced.

Generally, the stator windings of the DFIG are directly connected to the grid and the rotor windings are fed through bidirectional PWM voltage source converters (VSCs) to control the rotor and stator output power fed to the grid for variable speed operation [4], [2]. It is possible to control rotor current injection using fully controlled electronic converters to ensure effective operation in both sub and super-synchronous speed modes [4]. Decoupled control of active and reactive powers using the vector control is already discussed in detail by researchers [8], [9]. In a DFIG, both the stator and the rotor are able to supply active power, but the direction of this power flow through the rotor circuit is dependent on the wind speed and accordingly the generator speed. Below the synchronous speed, active power flows from the grid to the rotor side and rotor side converter (RSC) acts as the voltage source inverter while the grid side converter (GSC) acts as a rectifier but above the synchronous speed, RSC acts as the rectifier, and GSC acts as the inverter. The converter handles only around 25% of the machine rated power while the range of the speed variation is 33% around the synchronous speed [4]. An effective control strategy addresses the dynamics of a DFIG-based variable speed wind turbine and the operation of the converters under sub

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synchronous and super-synchronous modes of operation and during the transition period of these two modes.

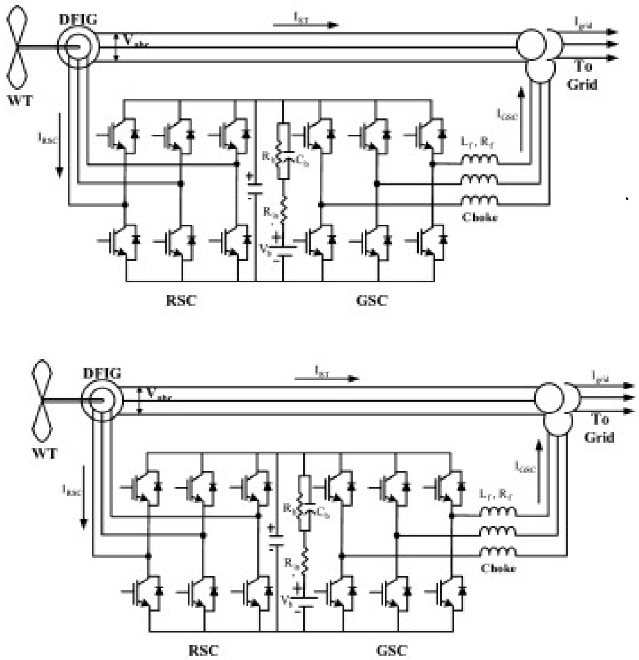

Fig. 1. DFIG-based WECS with a BESS (Thevenin's equivalent) in dc link for grid power leveling.

II. PRINCIPLE OF OPERATION OF PROPOSED SYSTEM

Fig. 1 shows a schematic of the DFIG with the rotor and grid side converters (RSC and GSC), a BESS in the dc link and a transformer and a choke (optional) in the rotor circuit. The BESS in the dc link is shown by its Thevenin equivalent [14], [15]. A configuration without the transformer in the rotor circuit (which accounts for the stator-rotor turns ratio of the DFIG) has also been reported in some literature. However, when the transformer is connected, the choke used for smoothening the currents of the GSC can be eliminated as the transformer leakage reactances would be sufficient enough for the cause. The rotor winding inductances act to smooth the currents of the RSC. This topology supports the complete control of the active and reactive powers of t he system with the rotor and grid side converters around 33% (nearly one-third) of the rated speed.

The principle of operation of this topology for grid power leveling is that, by incorporating a battery in the dc link, a constant power is fed to the grid always. The average power for a given place (where the wind turbine is installed) is calculated from the available wind speeds and this calculated average power is fed to the grid to reduce the power fluctuations on the grid. At the higher wind speeds (and the machine operating at super-synchronous speed), power output of the WECS is higher as compared to the average power and, therefore, the extra power is stored in the battery. In contrast, at the lower wind speeds (and the machine operating at sub synchronous speed) the power is drawn from the battery to maintain the average power fed to the grid. Thus it is ensured that the power fed to the grid is always "leveled," resulting in an efficient and reliable source of electrical power to the grid.

III. DESIGN ISSUES IN PROPOSED WECS CONFIGURATION

Since wind energy is a non reliable and unpredictable source of energy varying from time to time, stringent conditions are to be imposed in designing the proposed configuration of a WECS using DFIG with a BESS. Choosing the appropriate rating of the battery is of utmost importance as any discrepancy would lead to malfunctioning of the system. The major issues in designing the wind turbine and the BESS are as follows.

A. Design of Wind Turbine

The output power of the turbine and the wind velocity has the nonlinear relation. The output power of the turbine is given by the following equation [16]:

$$P_m = 0.5 * C_p(\lambda, \beta) * \rho A v^3 \tag{1}$$

where is Cp is power coefficient, ρ is air density, A is swept area of rotor blades, υ is the wind- velocity, λ is the tip speed ratio, and β is the pitch angle.

The power coefficient is defined as the power output of the wind turbine to the available power in the wind regime. This coefficient determines the "maximum power" the wind turbine can absorb from the available wind power at a given wind speed. It is a function of the tip-speed ratio and the blade pitch angle. The blade pitch angle can be controlled by using a "pitch-controller" and the tip-speed ratio (TSR) is given as

$$\lambda = \frac{\omega R}{v} \tag{2}$$

where ω is the rotational speed of the generator and R is radius of the rotor blades.

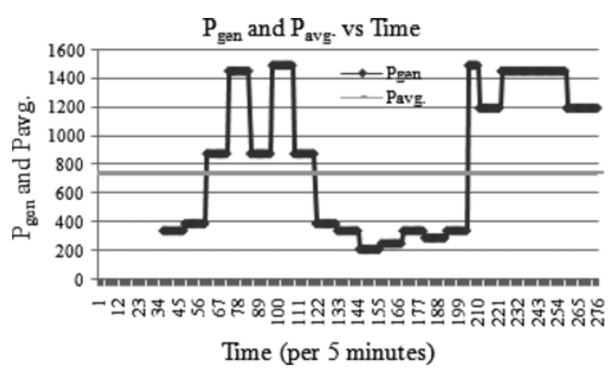

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Fig. 2. Characteristics of the power generated (P_{gen}) and average power (P_{avg}) for a day.

Hence, the TSR can be controlled by controlling the rotational speed of the generator. For a given wind speed, there is only one rotational speed of the generator which gives a maximum value of C_p, at a given β.
This is the major principle behind "maximum-power point tracking" (MPPT) and a wind turbine needs to be designed keeping this strategy in mind.

B. Design of BESS

As already explained, the design of a suitable rating of the BESS is very necessary for satisfactory operation of the proposed configuration of WECS. The rating of the BESS is decided by the total energy stored into it and this energy is stored for only those periods in which power generated by the machine is more than the average value that is to be fed to the grid. Initially, the average value of the power to be fed to the grid is calculated on the basis of the available wind speeds at that site.Knowing the value of this average power to be fed to the grid, is calculated as the required rating of the battery bank (E_b) is calculated as

$$E_b = \sum_{i=1}^{n} (P_{mi}) * t_i \tag{3}$$

where P_{mi} is the excess power at any instant (for every 5 min) than the average value of the power fed to the grid and t_i is the time period for which the excess power is produced. These data are considered for each 5 min as shown in Fig. 2 from a practical site.

At any instant the value of P_{mi} can be calculated as

$$P_{mi} = (P_{inst} - P_{avg}) \tag{4}$$

where P_{inst} is the instantaneous power of the wind turbine and P_{avg} is the average active power to be fed to the grid.

The design of the battery bank is on the basis of the additional power produced for a whole day to minimize the fluctuations on the grid; therefore, wind speed data for a day is taken. Data for the wind speed is taken for a place Bapatla (Andhra Pradesh) situated in India on a day 11 November 2009 [17]. The wind speed is measured at a height of 20 m by using anemometers. But generally wind turbines are installed at a higher height. Therefore, the data of the wind speed must be calibrated in terms of the general height of the wind turbine installed, which is given as

$$\frac{v}{v_c} = \left(\frac{h}{h_o}\right)^n \tag{5}$$

where υ is old wind speed at a height h, $υ_o$ is new wind speed at a height of h_o , and n is terrain factor.

A terrain factor(n) of 0.13 is selected for the wind speed calibration in this paper. The power outputs of the DFIG-based WECS for the different wind speeds are given in Table I. The average power (P_{avg}) is calculated from the power generated(P_{gen}) for a day 11 November 2009, and it is found to be nearly 750 kW for that day. The averaging of the power can be done for a month or a whole year. A characteristic is shown between P_{gen}, P_{avg} and time of the day (per 5 min) in Fig. 2. It shows the periods in which power output is more than the P_{avg} . During these periods, the battery must store the additional power and is to be delivered to the grid at low wind speed periods to maintain the P_{avg} on the grid. Accordingly, the rating of the battery bank is decided by using (3). In actual practice, it may be less than this value as the BESS is discharged in between too, as evident from Fig. 2.

TABLE I
POWER GENERATED AT DIFFERENT WIND SPEEDS

Time of the day	V_o at h_o	V at h	P_{gen} (kW)
12-1 A.M.	32.9	39.4	0
1-2 A.M.	28.3	33.9	0
2-3 A.M.	1.02	1.22	0
3-4 A.M.	5.14	6.2	340
4-5 A.M.	5.7	6.8	390
5-6 A.M.	12	9.8	880
6-7 A.M.	11.32	13.6	1460
7-8 A.M.	8.2	9.8	880
8-9 A.M.	12	14.3	1500
9-10 A.M.	8.2	9.8	880
10-11 A.M.	5.7	6.8	390
11-12 A.M.	5.14	6.2	340
12-1 P.M.	3.6	4.3	210
1-2 P.M.	4.2	5	250
2-3 P.M.	5.14	6.2	340
3-4 P.M.	4.6	5.5	290
4-5 P.M.	5.14	6.2	340
5-6 P.M.	12.35	14.8	1500
6-7 P.M.	10.3	12.3	1200
7-8 P.M.	11.32	13.6	1460
8-9 P.M.	11.32	13.6	1460
9-10 P.M.	11.32	13.6	1460
10-11 P.M.	10.3	12.3	1200
11-12 P.M.	10.3	12.3	1200

The minimum voltage level of the battery bank is decided by the line voltage of the grid and is given as

$$V_{dc} = \left(\frac{N_2}{N_1}\right)\sqrt{\frac{2}{3}}V_{line} \tag{6}$$

Where V_{dc} is the minimum required voltage of the battery bank, (N_2/N_1) is the transformer turns ratio, and V_{line} is the line voltage on the grid side.

On the basis of the dc link voltage required, the total number of the batteries in the series (N_{series})are calculated as

$$N_{series} = \frac{V_{dc}}{V_b} \tag{7}$$

Where V_b is the voltage of the single battery.

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The number of the batteries required in the parallel ($N_{parallel}$) are calculated as

$$N_{\mathrm{parallel}} = \frac{E_t * 1000}{V_{\mathrm{dc}} * P_b * \mathrm{MDOD}} \quad (8)$$

Where P_b is the capacity of the single battery in Ah and MDOD is the maximum depth of discharge of the battery, i.e., battery can be discharged only up to a maximum level generally, 80%for the Nickel-Cadmium batteries.

Thus a detailed and careful design of the BESS for a particular wind installation is to be performed.

IV. CONTROL STRATEGY

As shown in Fig. 3, the control strategy of the RSC and GSC consists of an “active and reactive power” controlling outer loop and the “current control” inner loop. A detailed explanation of the control strategy and the mathematical equations governing the same are presented below. The exclusive control feature of the DFIG is that simultaneous and decoupled regulation can be made for active variables(speed, active power, or torque) and reactive variables (voltage,reactive power, or power factor). This can be achieved by developing the control algorithm in a two axis synchronously rotating reference frame, in which each axis takes care of either the active or reactive powers control. When the rotor power is allowed to flow in both directions, the control can be realized over a wide range of the rotor speeds, above and below and synchronous speed.

A. Control of GSC

The distinct feature of this work lies in modifying the active power outer loop of the GSC. The grid power is regulated to be a fixed value (determined by the average power as calculated earlier) and this is given as the reference active power. This is then compared with the actual grid power at any instant and the error is processed using a proportional-integral (PI) controller to generate the q-axis component of the reference grid current.

For the reactive power outer-loop control of the GSC, the controlled variable can be the stator reactive power. When it is controlled, the reactive power set point can be obtained in different ways depending on the power sharing strategy with the GSC. The desired reactive power sharing scheme (between theDFIG stator and the GSC) can be chosen, provided the total reactivepower matches the requirement of the network ($Q_{total} = Q_{stator} + Q_{GSC}$) and is within the operating limits.

The d and q components of the reference grid currents to be given to the PWM controller of the GSC are obtained from the reference active and reactive powers components. The system considered in this work has both an active and a reactive powers loop. The active power loop of the system includes the grid power regulation to obtain “grid power leveling.”The reference reactive power (Q_{ref})can be set to zero for the unity power factor operation.

The expression for the reference q-axis grid current is as

$$i_{\mathrm{gqref}} = \left(K_{\mathrm{pp}} + \frac{K_{\mathrm{ip}}}{s}\right)(P_{\mathrm{gref}} - P_{\mathrm{grid}}) \quad (9)$$

Where K_{pp} and K_{ip} are the proportional and integral constants of the grid power regulator, respectively.

The reference d-axis grid current is chosen according to the reactive power sharing between the stator and the GSC, and it can be chosen to be zero, for a unity power factor operation.

These reference currents are then compared with the sensed grid side currents and the obtained error signal is processed with a PI controller to generate the control voltages for the PWM generator on the grid side. The expressions for the control voltages in d-q frame are given as

$$v_{\mathrm{dgsc}} = \left(K_{\mathrm{pgsc}} + \frac{K_{\mathrm{igsc}}}{s}\right)(i_{\mathrm{gdref}} - i_{\mathrm{gd}}) \quad (10)$$

$$v_{\mathrm{qgsc}} = \left(K_{\mathrm{pgsc}} + \frac{K_{\mathrm{igsc}}}{s}\right)(i_{\mathrm{gqref}} - i_{\mathrm{gq}}) \quad (11)$$

Where i_{gd} and i_{gq} are the sensed components of the grid currents and K_{pgsc} and K_{igsc} are the proportional and integral constants of the grid side current regulator respectively. These control voltages are fed for PWM generation of the GSC, as shown in Fig. 3.

B. Control of RSC

The RSC is a dedicated controller for the “machine” and hence the active and reactive power outer loops are chosen to extract the maximum power from the wind and to maintain a unity power operation of the stator. The active power set point can be obtained from the instantaneous value of the rotor speed and the rotor currentis controlled in the stator flux-oriented reference frame to obtain the desired active power according to the optimum torque speed characteristics. The set point for the reactive power can be calculated from the active power set point and a desired power factor (considered to be unity in the present work). In the stator flux-oriented reference frame, the axis rotor current is used to control the required reference reactive power(Q_{ref}).

The reference rotor currents (q and d components, respectively) are generated from the reference active and reactivepower set points as

$$i_{\mathrm{rqref}} = -\frac{L_s}{v_s L_m} P_{\mathrm{sref}},\; i_{\mathrm{rdref}} = \frac{\phi_s}{L_m} - \frac{L_s}{v_s L_m} Q_{\mathrm{sref}} \quad (12)$$

These reference values of rotor currents are compared with the sensed values of rotor currents and the obtained error signal is processed with a PI controller to generate the control voltages for the PWM generator on the rotor side.The expressions for the control voltages in d-q inframe are given as

$$v_{\mathrm{drsc}} = \left(K_{\mathrm{prsc}} + \frac{K_{\mathrm{irsc}}}{s}\right)(i_{\mathrm{rdref}} - i_{\mathrm{rd}}) \quad (13)$$

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$$v_{qrsc} = \left(K_{prsc} + \frac{K_{irsc}}{s}\right)(i_{rqref} - i_{rq}) \tag{14}$$

Where i_{rd} and i_{rq} are the sensed d-q components of the rotor currents and K_{prsc} and K_{irsc} are the proportional and integral constants of the rotor side current regulator, respectively. These control voltages are fed for PWM generation of the RSC, as shown in Fig. 3.

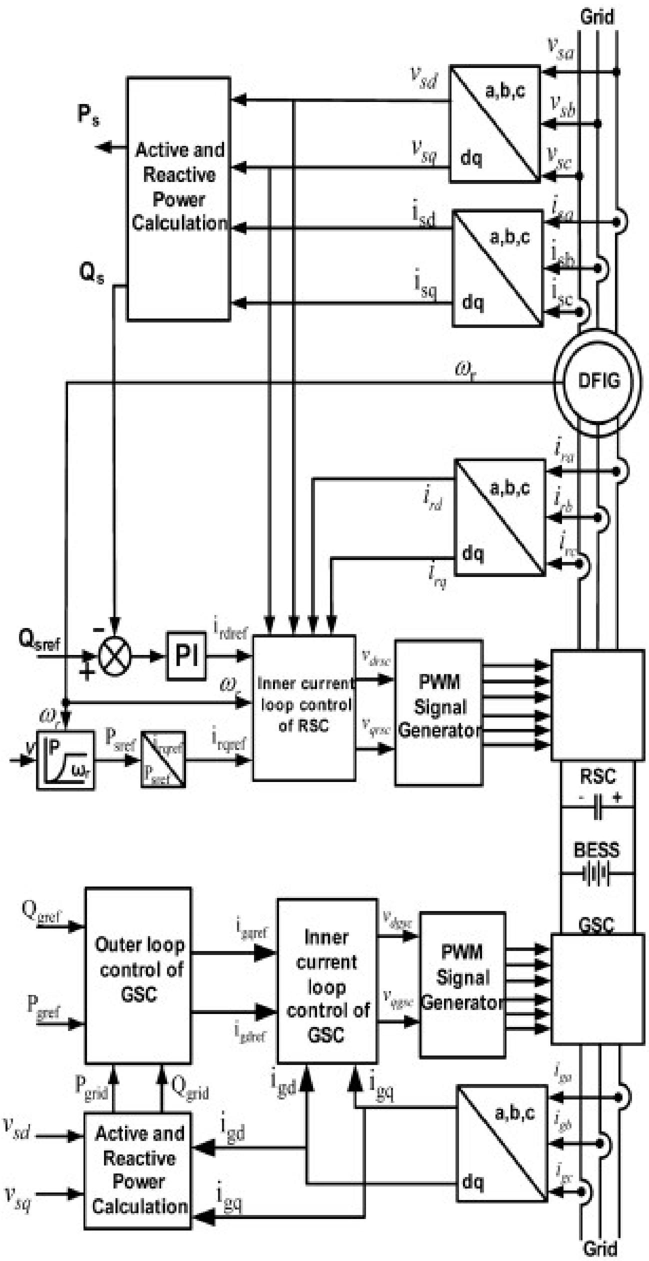


Fig. 3. Schematic diagram of proposed control strategy for RSC and GSC of a DFIG in a WECSS using BESS.

V. MATHEMATICAL MODELING OF DFIG

A simplified mathematical model would help in efficient analysis of the behavior of any complex system, under different operating conditions and control strategies. For a DFIG, the most common way of deriving a mathematical model is in terms of direct and quadrature axes (dq axes) quantities in a frame which rotates synchronously with the stator flux vector.An equivalent circuit for the DFIG in the synchronousreference frame [19] is represented in Fig. 4.

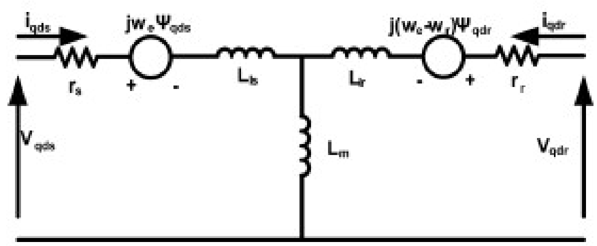


Fig. 4. Complex synchronous equivalent of a DFIG [19]

The expressions related to this model are as

$$v_{qds} = r_s i_{qds} + j\omega_e \psi_{qds} + \frac{d}{dt}(\psi_{qds})$$
$$v_{qdr} = r_s i_{qdr} + js\omega_e \psi_{qdr} + \frac{d}{dt}(\psi_{qdr})$$
$$\psi_{qds} = L_s i_{qds} + L_m i_{qdr}$$
$$\psi_{qdr} = L_r i_{qdr} + L_m i_{qds}$$
$$T_e = \frac{3}{2}\frac{p}{2}\mathrm{Re}[j\psi_{qds} \cdot \overline{i_{qds}}] = \frac{3}{2}\frac{p}{2}\mathrm{Re}[j\psi_{qdr} \cdot \overline{i_{qdr}}] \tag{15}$$

And i_{qds} are i_{qdr} the complex conjugates of the stator-curerent and rotor-current space vectors and stator and rotor inductances are defined as

$$L_s = L_{ls} + L_m \qquad L_r = L_{lr} + L_m. \tag{16}$$

The complex torque equation of (15) can be resolved in reference d-q leading to

$$T_e = \frac{3}{2}\frac{p}{2}(\psi_{ds} \cdot i_{qs} - \psi_{qs} \cdot i_{ds}) = \frac{3}{2}\frac{p}{2}(\psi_{dr} \cdot i_{qr} - \psi_{qr} \cdot i_{dr}). \tag{17}$$

The stator side active and reactive powers are given as

$$P_s = \frac{3}{2}\mathrm{Re}[v_{qds} \cdot \overline{i_{qds}}] = \frac{3}{2}(v_{qs} i_{qs} + v_{ds} i_{ds})$$
$$Q_s = \frac{3}{2}\mathrm{Im}[v_{qds} \cdot \overline{i_{qds}}] = \frac{3}{2}(v_{qs} i_{ds} - v_{ds} i_{qs}) \tag{18}$$

Considering that

$$\overline{i_{qds}} = \frac{1}{L_s}\overline{\psi_{qds}} - \frac{L_m}{L_s}\overline{i_{qdr}}. \tag{19}$$

The active and reactive power equations are modified as

$$P_s = \frac{3}{2}\left\{\frac{1}{L_s}(v_{qs}\psi_{qs} - v_{ds}\psi_{ds}) - \frac{L_m}{L_s}\{v_{qs}i_{qr} + v_{ds}i_{dr}\}\right\}$$
$$Q_s = \frac{3}{2}\left\{\frac{1}{L_s}(v_{qs}\psi_{qs} + v_{ds}\psi_{ds}) - \frac{L_m}{L_s}(v_{qs}i_{dr} - v_{ds}i_{qr})\right\} \quad (20)$$

Thus, the magnitudes of stator currents govern the active and reactive powers of the stator, and these currents depend on the rotor currents. Thus, the active and reactive powers can be controlled by appropriately controlling the rotor currents (i_{qr} and i_{dr}) in WECS.

VI. MATLAB-BASED MODELING

The MATLAB-based modeling of the proposed configuration of DFIG-based WECS with a BESS consists of a mechanical system (wind turbine) and the electrical system (DFIG with back-to-back voltage source converters) and also the Thevenin's equivalent of a BESS.

A. Wind Turbine Modeling

The mechanical power output of the wind turbine is given by (1) and in that equation the power coefficientis $C_p(\lambda,\beta)$ very important parameter. The power output of wind turbine is dependent on the power coefficient given as [20]

$$C_p(\lambda,\beta) = c_1\left(\frac{c_2}{\lambda + c_8\beta} - \frac{c_2c_9}{\beta^3+1} - c_3\beta - c_4\beta^{c_5} - c_6\right) * e^{\left(\frac{-c_7}{\lambda+c_8\beta} + \frac{c_7c_8}{\beta^3+1}\right)} + c_{10}\lambda$$

Where λ is the tip speed ratio and given by the (2). The maximum value of $C_{p\ (Cpmax=0.48)}$ is for β=0 degree and λ=8.1. This particular value of is λ defined as the nominal value(λ_{nom}). The coefficients used in (20) are given in Appendix A. The turbine parameters are given in Appendix B. The turbine parameters selected are for a 1.5-MW wind turbine manufactured by the Suzlon India Ltd. (S82) [21].

B. Battery Bank Design and Modeling

A detailed procedure to select the rating of the BESS was already mentioned in earlier sections. The MATLAB-based modeling of the battery is done using the Thevenin's equivalent of it as shown in Fig. 1. Since the battery is an energy storage unit,its energy is represented in kWh, when a capacitor is used to model the battery unit, the capacitance (C_b) can be determined from

$$C_b = \frac{(\mathrm{kWh}) \times 3600 \times 10^3}{0.5\left(V_{ocmax}^2 - V_{ocmin}^2\right)} \quad (22)$$

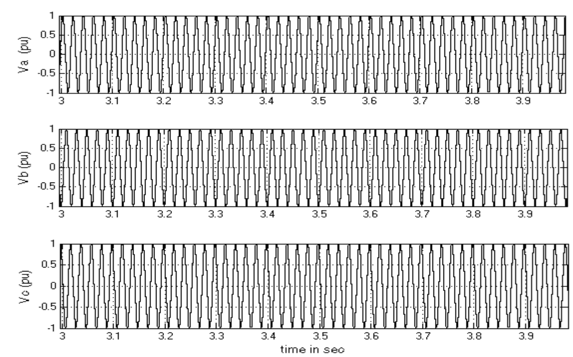
Where V_{ocmin} and V_{ocmax} are the minimum and maximum open where circuit voltage of the battery under fully discharged and charged conditions. In the Thevenin's equivalent model of the battery,R_s is the equivalent resistance external internal of parallel/series combination of a battery, which is usually a small value. The parallel circuit of R_b and C_b is used to describe the stored energy and voltage during charging or discharging.R_b.in parallel with C_b represents self-discharging of the battery. Since the self-discharging current of a battery is small, the resistance is large. The design details of the BESS used in this work
are given in Appendix C.

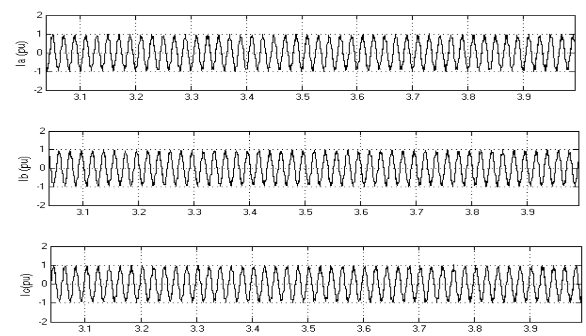
C. Electrical System Modeling

The electrical system modeling is carried by using the sim power system toolbox of MATLAB-SIMULINK. The parameters of DFIG used in the model are given in Appendix D. The discussed control strategy is implemented on the RSC and the GSC. The developed model is tested for the proposed control strategy to achieve "grid power leveling" under different speeds of operation of the generator and the results are presented in detail in the next section.

VII. RESULTS AND DISCUSSION

The model of WECS with BESS shown in Fig.3 is developed in the MATLABSIMULINK as described in Section VI and results are presented to demonstrate its behavior at different wind speeds.





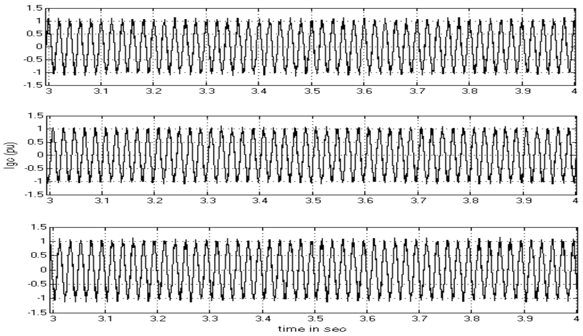
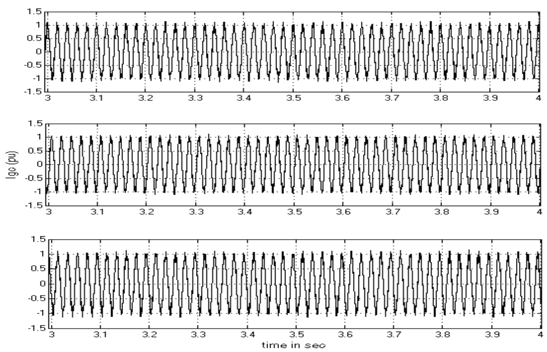
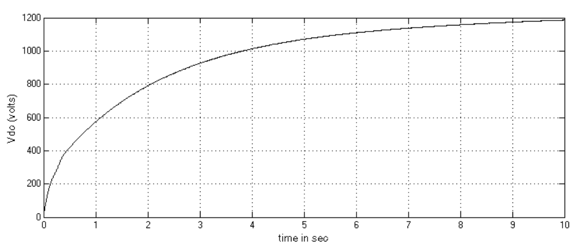
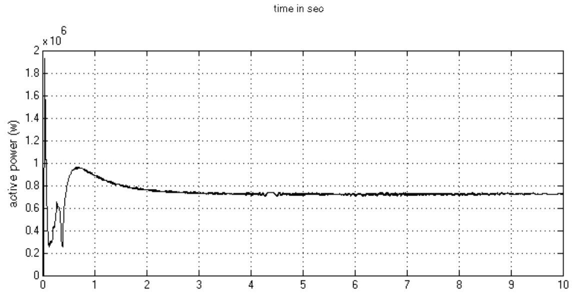


fig..5.shows stator voltage(V_{abc}),gridcurrent(I_{grid}) and ,gridside converter current(I_{GSC})in all three modes.

Figs. 5, 6, 7, 8 and 9 show the performance of the proposed configuration of a DFIG-based WECS at subsynchronous speed, super-synchronous speed, and during transition i.e., at synchronous speed, respectively. The waveforms for stator voltage(V_{abc}),gridcurrent(I_{grid}),gridside converter current(I_{GSC}), rotor side converter current(I_{RSC}),stator current(I_{ST}),rotor speed (ωr), dc link voltage(V_{dc}), reactive power(Q), grid







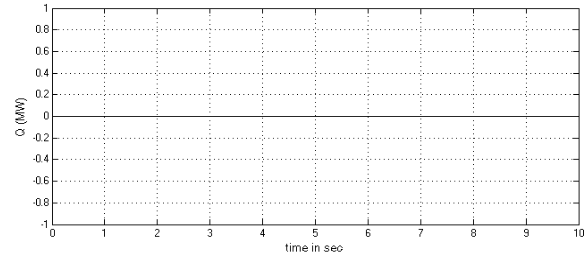


Fig.6.shows rotor side converter current(I_{RSC}),stator current(I_{ST}), dc link voltage(V_{dc}), reactive power(Q) in all three modes.

power(P), and battery power (P_{bat}) are presented for different wind speeds. The convention for the battery power is chosen as to be negative if the battery discharges any power to the grid and positive if power is stored in the battery.

In all three cases, the value of the grid power is maintained to be constant at 0.75 MW by the modified grid power control strategy. However, this is maintained by either charging or discharging the battery in the corresponding

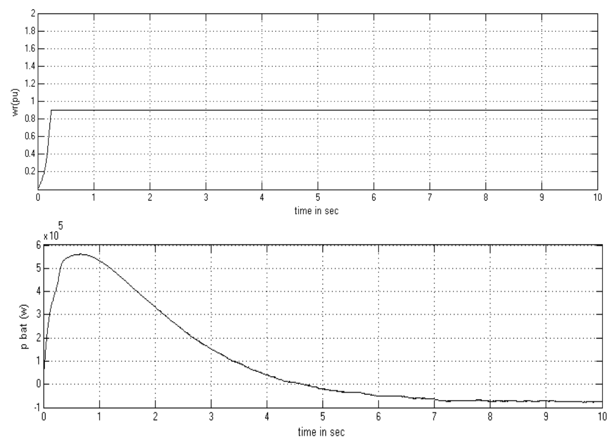
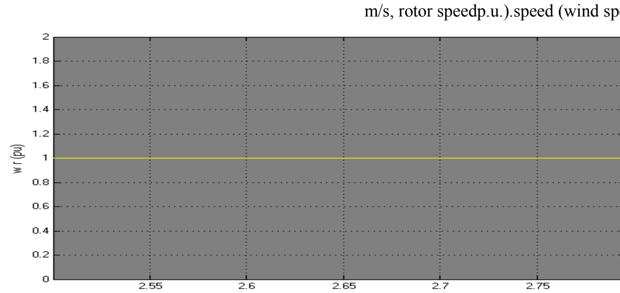


Fig.7.shows waveforms of rotor speed(ωr) and battery power (P_{bat}) in subsynchronous mode.

Fig. 5. Performance of a DFIG-based WECS with a BESS at subsynchronous m/s, rotor speedp.u.).speed (wind speed



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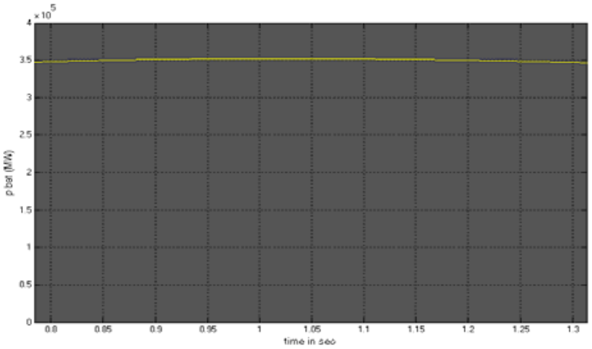

Fig.8.shows waveforms of rotor speed(ωr) and battery power (P_{bat}) in synchronous mode.

region of operation. The reactive power is maintained at a stable value of zero, demonstrating a unity power factor operation. The analysis has been performed at variable wind speeds and the grid power is maintained to be constant at the reference value. The reference grid power can be chosen to be the average power supplied by the wind turbine to feed the constant power to the grid during the total period of operation. Hence, the grid power reference is chosen to be 0.75 MW as calculated and satisfactory results are obtained as shown in Figs. 5–7.

It can be argued over the results that, though the wind speed varies from a low to high during a given period of time, the power fed to the grid and hence the overall energy supplied to the grid, remains constant irrespective of these variations in wind speed. Thus the modified control strategy is

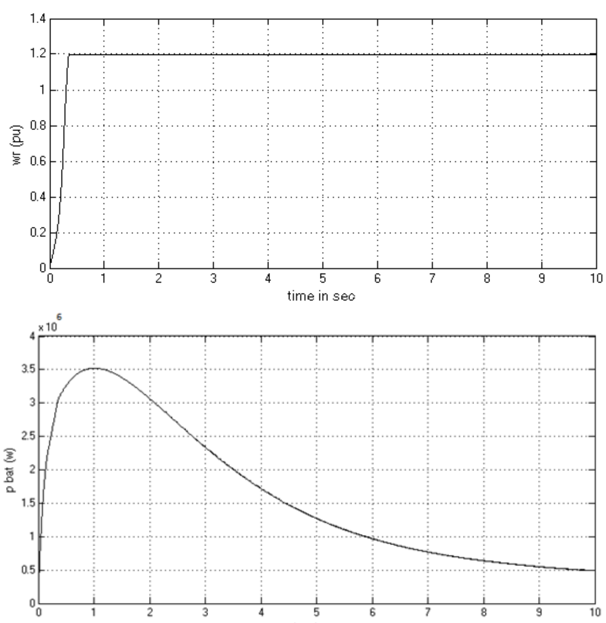

Fig.9.shows waveforms of rotor speed(ωr) and battery power (P_{bat}) in super synchronous mode.

able to negotiate the grid power gusts due to the variable wind speeds in an efficient way.

CONCLUSION

A configuration of a DFIG-based WECS with a BESS in the dc link has been proposed with a control strategy to maintain the grid power constant. Design the BESS has been proposed by considering practical data at an installation point. The performance of the proposed control strategy on a DFIG-based WECS with BESS has been demonstrated under different wind speeds. This paper has also addressed the major disadvantage of connecting a DFIG to the grid, the “grid power gusts” due to the wind speed variations. If the grid fails to maintain the grid power constant, then during periods of “over-generation,” the consumers are to be paid in return to implement “load-leveling,” and absorb the excess power. This is an unbeneficial practice as the supplier looses both energy and money.

The proposed configuration and control strategy, however, mitigates a need for this, by supplying a constant power to the grid throughout and thus maintaining a constant flow of energy to the grid irrespective of the variations in the wind speed. Moreover, other important control strategies like the maximupower point tracking (MPPT) and unity power factor operation at the stator terminal are also satisfactorily observed. Placing a BESS in the dc link of a DFIG-based WECS, proves to be a satisfactory implementation in terms of maintaining a constant power at the grid, set aside the disadvantages of using high rating of BESS.

APPENDIX

A. Coefficients in the Empirical Expression for the Power Coefficient(C_p)

$c_1 = 0.5176, c_2 = 116, c_3 = 0.4, c_4 = 0, c_5 = 0, c_6 = 5, c_7 = 21, c_8 = 0.08, c_9 = 0.035, \quad c_{10} = 0.0068$

B. Parameters of the Wind Turbine

Parameter	Value
Rated Power	1500 kW
Cut-in Wind Speed	4 m/s
Rated Wind Speed	14 m/s
Cut-out Wind Speed	20 m/s
No. of Blades	3
Rotor Diameter	82 m
Swept Area	5281 m^2

C.Parameters of the battery

Parameter (notation)	Value
Battery Nominal Voltage (V_b)	1200 V
Internal Resistance (R_b)	10000Ω
Internal Capacitance (C_b)	675000F
Battery Series Resistance (R_s)	0.00094Ω

D.Parameters of the DFIG

Parameter (unit)	Value
Rated Power (MW)	1.5
Stator Voltage (V)/Frequency (Hz)	575/50
Stator/Rotor turns ratio	0.38
Pole numbers	4
Stator Resistance (pu)	0.00706
Rotor Resistance (pu)	0.005
Stator leakage Inductance (pu)	0.171
Rotor leakage Inductance (pu)	0.156
Magnetizing Inductance (pu)	2.9
Lumped Inertia Constant (s)	5.04

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IMPLEMENTATION OF PERSONALIZATION IN WEB USAGE MINING USING FUZZY LOGIC

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***ABSTRACT*-This paper presents implementation of Fuzzy logic in web personalization. Web personalization is a process of getting access to a requested page during the browsing of web pages. In order to achieve quick access to the requested webpage, log details of user is used as the a priori data. Conventional statistical methods are available to access the requested webpage. However, due to the vast number of users accessing a particular website, intelligent techniques have to be developed for handling huge amount data. In this paper, Fuzzy logic approach has been used for web personalization.**

Keywords: Web server log, Web usage mining, Data mining, e-learning, Fuzzy logic

1. INTRODUCTION

E-learning is the method of a remote realization of didactic process with the usage of computer technology that enables a direct contact between a teacher and a learner in real time. In this training process, different techniques based on text, image, video and sound are used. From a technical point of view, e-learning system is composed of a user application that provides user communication with the e-learning system; e-learning application servers which aim to interpret user queries and sending HTML code to a client; e-learning content servers that give an access to files with training materials; and database server that stores information about servers names and names of users; authorizations to manage the users, didactic contents and training procedures. These servers contain metadata connected with contents and a progress of learner training.

Web-based education systems has been growing drastically [Tang, 2005]. The system consists huge amount of information. Due to vast quantities of data it is very difficult to manage manually. The use of data mining [Romero, 2007] is in great demand. Various data mining methods are available [Tane, 2004].

Personalization in e-learning systems

Personalization is learner-specific strategies to address individual needs and expectations to support and to promote individual learning success. Personalization consists in establishing individual path of learner training on the basis on its personality and training progress. This process may refer to an individual content selection planning from existing repositories, as well as to a dynamic change of repositories contents. Personalization of learning expresses an individual approach to the learner in e-learning systems. It includes all actions designed to match the selected aspects of e-learning course to individual user's needs and opportunities.

Personalization can be done on-line. In this case, the system monitors the learner and system interaction in real time and adapts learning path according to the characteristics of the learner. Reasoning mechanism, ontology for the content of courses and data mining methods for tracking references to a web page are applied in the off-line mode. The system collects learner's data, analyzes them and recommends a teacher changes in the course content. [Tzouveli, 2004; Ueno, 2004].

Web usage mining

Web usage mining [Kosala, 2000] generates server log automatically. It discovers usage patterns. It uses the data from servers access logs, proxy server logs, browser logs, user profiles [Nasraoui, 2008] registration data, user session or transaction cookies, user queries or book mark data. The data records the identity of Web users. Complete history of file accesses by the user is created. Most WWW access logs follow the Common Log Format. Some of the typical data collected are IP addresses, user id, URL page references, protocol used and access time of the users. The usage data collected represent the navigation patterns of different segments of the overall web traffic.

Web usage mining techniques [Yu, 2008] capture usage patterns from users' navigational data; have achieved great success in various application areas such as Web personalization and recommender systems, link prediction and analysis, Web site evaluation or reorganization, to improve the web performance, the search engines, cross marketing strategies across products.

Web mining is used in Web Search, Classification, E-Learning and Personalization. It discovers knowledge from the Web hyperlink structure, page content and usage log. Itis used in Intelligent Web Search, Personalization, Recommendation Engines, Web commerce applications, Building the Semantic Web, Web page classification and categorization, News classification and clustering [Jyoti, 2009; Ratnakumar, 2005], Information / trend monitoring, Analysis of online communities, Web and mail spam filtering.

Web personalization

The increasing popularity of the Internet and the exponential increase in the number of its users has led to the creation of new paradigms of knowledge discovery, like Web personalization, mining bookmarks, mining e-mail correspondences, and recommendation systems. These are grouped as Web Usage mining. Mining typical user profiles and URL associations from the vast amount of access logs is an important component of Web personalization that deals with tailoring a user's interaction with the Web information space based on information about user. Nasraoui et al, 2000, defined a user session as a temporally compact sequence of Web accesses by a user and used a dissimilarity measure between two Web sessions to capture the organization of a Web site.

Personalization requires implicitly or explicitly collecting visitor information and leveraging that knowledge in content delivery framework to manipulate what information is present to users and how it is presented. A personalization mechanism is based on explicit preference declarations by the user and on an iterative process of monitoring the user navigation, collecting its requests of ontological objects and storing them in its profile in order to deliver personalized content [Antoniou, 2010].

One of the recent advances throughout this decade has been the evolution of the web personalization to address the requirement of effective web navigation and now the web personalization has become an indispensable tool for both Web-based organizations and for the end users to deal with the content overload. Web personalization is the approach to tackle the problem of content overload by predicting the user needs by taking advantage of the knowledge acquired from the analysis of the users' explicit and implicit access behaviors in combination with the content and the structure of the Web site. The Web personalization [Mobasher, 2004] can be defined as any action that tailors the Web experience to a particular user, or a set of users [Mobasher, 2000]. Web personalization can be seen as broad area that includes several interdisciplinary research domains from information retrieval, data mining human machine interactions, social networks and recommender systems as special cases.

Personalization requires implicitly or explicitly collecting visitor information and it uses the Users' behavior in different applications such as Personalization, content delivery as per users' interests, e-commerce, e-business, e-learning to improve the system and to improve the system design as per their interest because the site owners are more interested than ever in making their sites automatically predict future navigational patterns of the users to improve the usability, structure, and user retention of their sites. One research area that has recently contributed greatly to web personalization is web mining [Jaideep, 2000].

II. RELATED WORKS

The research in the area of web mining and its applications to web personalization has been well documented and reported. "Analog" was one of the leading personalization systems based on the web usage mining methodology. The analysis of log data discovers valuable web usage patterns [Weld, 2003]. Mobasher implemented the web usage-based Web personalization system called Web Personalizer for recommending Web pages on Server-Side to users. The Web Personaliser provides a personalization framework based on web log mining and using data mining techniques for extraction of knowledge for generating the recommendations to current users based on their browsing navigational history. Initially the web usage mining was not considered extensively for personalization rather its primary focus was on the extraction of decision-support knowledge, expressed in terms of descriptive data models to be evaluated and exploited by human

experts but in the recent time the researcher have focused more on the application of web usage mining for web personalization to acquire the required robustness and flexibility. Several web personalization projects have been developed corresponding to the evolution of extensive research in Web usage mining.

In Web usage mining, the main component of a web personalization system, is generally, a three step process, consisting of data preparation, pattern discovery, and pattern analysis. The web usage mining extensively focus on discovering the interesting patterns in order to understand the users' navigational behavior. The navigational behavior play an important role in the decisions concerning site restructuring or modification. A semantic web personalization framework is also presented [Sarabjot, 2007], which enhances the recommendation process with content semantics. These have suggested that the structural characteristics of Web sites, such as the site topology and the degree of connectivity, have a significant impact on the relative performance of recommendation models.

The machine learning techniques have been applied along with soft computing techniques to properly deal with the imprecision, uncertainty and partial truths underlying the personalization process. The fuzzy logic and neuro-fuzzy is becoming popular for the web personalization system. The neuro-fuzzy strategy has been applied to develop a Web personalization system that dynamically suggests interesting URLs for the current user.

Veeramalai, 2011, proposed the Fuzzy-Temporal Association Rule Mining Algorithm (FTARM) to classify the Web user profiles dataset periodically to know the users behaviors and interests based on temporal pattern analysis. FTARM is used for reducing the search space of the Web user profiles dataset in which Fuzzy logic is used for intelligent classification.

Personalization for a user can be achieved through web usage mining. Mass customization and personalization performed by dynamic Content Web site by making clusters of users with similar access patterns and by adding navigational links [Masseglia, 1999].

III. MATERIALS AND METHODOLOGY

Source of Data for Web Usage Mining

Web data can be classified as content data, structure data, user profile data and usage data. Web usage data is the collection of data that describes the usage of web resources. The usage data which is used for mining purposes can be collected at different levels i.e. Server level, Client level or Proxy level.

Server Level Collection

Access log files at server side are the basic information source for Web usage mining. These files record the browsing behavior of site visitors. Data can be collected from multiple users on a single site. Log files are stored in various formats such as Common log or combined log formats. Following is an example line of access log in common log format.
123.456.78.9-[25/Apr/1998:03:04:41 -0500]
"GET/HTTP/1.0" 200 3290
This line consist the following fields: Client IP address, User id ('-'if anonymous), Access time, HTTP request method, Path of the resource on the Web server, Protocol used for the transmission, Status code returned by the server, Number of bytes transmitted. Modern Web servers like Apache supports combined log format by inserting further variable values. User agent and Referrer are the examples of such variables. When customization was not possible, referring URL's and user agents stored in different log files namely referrer log and agent log respectively.

IV. DATA PREPROCESSING

User Identification: IP address, User agents and referring URL fields of log file are used to identify user. There are some problems which can arise in user identification. ISP's which uses Dynamic Host Configuration Protocol technology, it is difficult to identify same user through different TCP/IP connections because IP address changes dynamically (single IP address/multiple server session). It is also possible that IP address of a user changes from connection to connection (multiple IP address/single user). Different IP address can be assigned for every single request performed by the user (Multiple IP address/single server session). Moreover, same user can access the Web by using different browsers from the same host (multiple agent/single users).

User Session Identification: Log entries of the same user are divided into sessions or visits. A time out of 30 minutes between sequential requests from the same user is taken in order to close a session

User's Web Log Analysis: Web log records each transaction, which was executed by the browser at each web access. Each line in the log represents a record with the IP address, time and date of the visit, accessed object and referenced object. In such data, we follow sequences in visiting individual pages by the user, who is, identified by the IP address. The data from Web logs, in its raw form, is not suitable for the application of usage mining algorithms. The data need to be cleaned and preprocessed. To perform log data analysis, the data pre-processing process must be accomplished. The data pre-processing is the process of cleaning and transforming raw data sets into a form suitable for web mining. The task of the data pre-processing module is therefore, to obtain usable datasets from

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raw web log files, which, in most cases, contain a considerable amount of incomplete and irrelevant information. Once web logs are preprocessed, useful web usage patterns may be generated by applying data mining techniques. Table 1 shows a sample of web log data after preprocessing process.

Log file: A log file is a record of everything that goes in and out of a particular server. The information is frequently recorded chronologically, and is located in a directory. The server administrator has regular access to the log file. Log files are also important to keeping track of applications that have little or no human interaction, such as server applications. There are times when log files are too difficult to read or make sense of, and it is then that log file analysis is necessary. Log file analysis is generally performed by computer program that makes the log file information more concise and readable format. Log files can also be used to correlate data between servers, and find common problems between different systems that might need one major solution to repair them all. A Web log file records activity information when a Web user submits a request to a Web server. A log file can be located in three different places: i) Web servers, ii) Web proxy servers, and iii) client browsers.

Log Files Description: The data recorded in server logs reflects the access of a Web site by multiple users. Web server-side data and client-side data constitute the main sources of data for Web usage mining. Web server access logs constitute the most widely used data because it explicitly records the browsing behavior of site visitors. For this reason, the term Web log mining is sometimes used. Web log mining should not be confused with Web log analysis.

Algorithm for Codification of Web Logs

Input: Web log records collected from the web server

Step 1: Select the logs that contain users' requests of pages with status code 200.

Step 2: Group by IP address of the logs.

Step 3: Codify the requested page with Meta data of the web site.

Step 4: Store only important features such as, IP address, visited page and date of visit into the web server.

Output: Codified web logs.

The codification is done in offline at a periodic interval to update the user interest which may change time to time. Figure 1 shows the look of raw web logs that are extracted from web server and stored in MS-Excel. Figure 2 shows page name versus page ID.

Selection of web logs from raw web logs are done in step 1. The set of rules are followed, to select logs. They are as follows:

I. Logs do not contain the requests of image files (.jpg, .gif and etc.,)
II. Logs that are not generated anonymously (robots.txt.) and
III. Logs that contain status code is equal to 200.

The users are identified by the IP address and sessions are identified by date of visit. In step 2, users' recent activities are grouped and ordered chronologically. Step 3 is implemented with the help of the information about HTTP status code. Figure 3 represents the status after the completion of step 4. Using Matlab software, selection and transformation algorithm is applied to have usage patterns of the respective IP address. The sample output is given in Table 1.

Table 1 shows sample codified data of each session. The numbers represent the webpages. The numbers in Table 1 represent webpage numbers. The codified data has been dealt separately for each user and all subsequent training and testing of the algorithms are done for each user. The results are stored exclusively for each user. During offline testing, the trained results of the respective user are used for next web page suggestion. All the users' codified data are combined and training of the proposed algorithms is done to store the trained results that can be used in common during offline testing. In this situation, the page visit data of all the sessions of all the users are combined. Unique session numbers are selected using statistical variance method. These unique session numbers are used for training and testing the proposed algorithm.

V. FUZZY LOGIC

The concept of fuzzy logic appeared following the development of the concept of a fuzzy set by Zadeh in 1965. Fuzzy sets serve as a means of representing and manipulating data that are not precise but fuzzy. Fuzzy logic is a form of multi-valued logic that allows intermediate values to be defined between conventional evaluations such as true/false, yes/no, high/low, and big/small. Notions such as rather tall or very fast can be formulated mathematically and processed by computers in order to apply a more human-like way of thinking in computer programming. Fuzzy logic theory addresses reasoning in the context of real-life uncertainty. Fuzzy logic has rapidly become one of the most successful of today's technologies for developing sophisticated control systems. The reason for which is very simple. Fuzzy logic addresses such applications perfectly as it resembles human decision making with an ability to generate precise solutions from certain or approximate information. It fills an important gap in engineering design methods left vacant by purely mathematical approaches, and purely logic-based approaches in system design. While other approaches require accurate equations to model real-world behaviors, fuzzy design can accommodate the ambiguities of

real-world human language and logic. It provides both an intuitive method for describing systems in human terms and automates the conversion of those system specifications into effective models. A fuzzy set is defined by a membership function that maps objects in a domain of concern to their membership value in the set. Membership functions are classified into several types, such as a bell membership function, a triangular membership function, and a trapezoid membership function.

Fuzzy systems can be represented as networks with four hidden units. Each one of them receives the inputs x_1, x_2 and x_3 which correspond to the fuzzy categorization of a specific number. The fuzzy operators are evaluated in parallel in the hidden layer of the network, which corresponds to the set of inference rules. The last unit in the network is the defuzzifier, which transforms the fuzzy inferences into a specific control variable. The importance of each fuzzy inference rule is weighted by the numbers α1, α2, and α3 as in a weighted centroid computation. The defuzzifier operator in the last layer can be approximated with standard units.

Training Fuzzy logic for web personalization

Step 1: Read the preprocessed web log value.

Step 2: Create Fuzzy membership function.

Step 3: Create clustering using K-Means algorithm.

Step 4: Process with target values.

Step 5: Obtain final weights.

Testing Fuzzy logic for web personalization

Step 1: Input a pattern (web log value).

Step 2: Process with Fuzzy membership function.

Step 3: Find the cluster to which the pattern belongs.

Step 4: Obtain estimated target values.

Step 5: Estimate the web page.

VI. RESULTS AND DISCUSSION

Figure 4 to 5 presents the frequency versus pages visited by different users. The x-axis represents the webpage numbers and y-axis represents frequency of visit by users. Figure 6 presents the web page estimation output compared to target webpage.

VII. CONCLUSIONS

This paper presents implementation of fuzzy logic for personalization of web usage mining. Training and testing patterns have been collected from the log of Protechsc website. These data are preprocessed to remove unwanted information. The data is separated into training and testing patterns. Fuzzy logic is trained with the training patterns to obtain final weights. These final weights are used for testing the prediction of webpage when a test pattern is presented. The performance of the fuzzy logic is based on the radii used.

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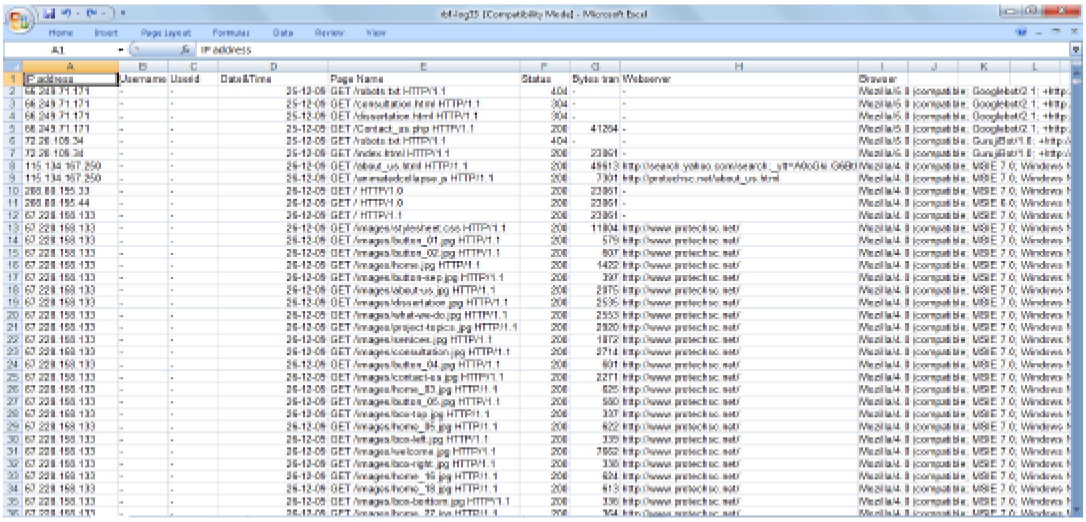

Fig.1 Raw web logs

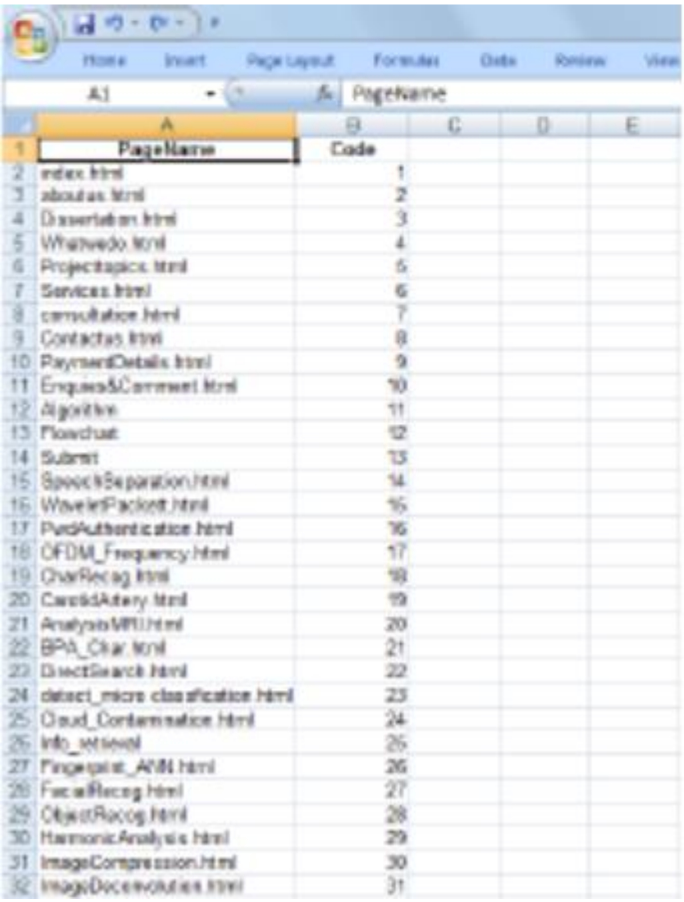

Fig.2 Page name vs Page ID

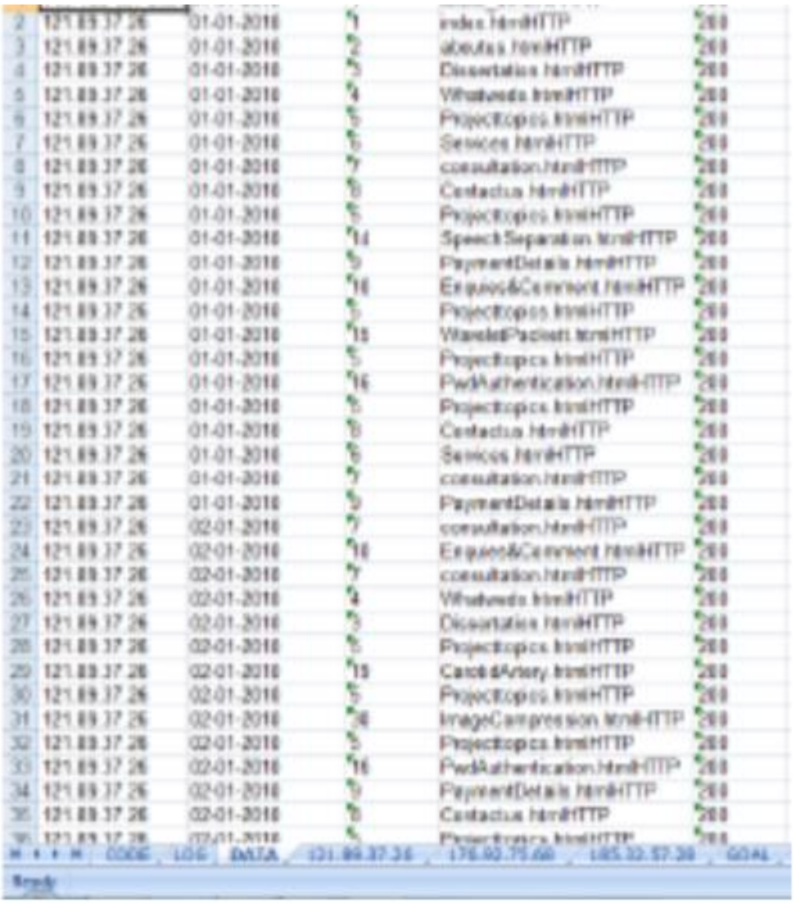

Fig.3 Filtered logs

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7 ,10, 7, 4, 3, 5,19, 5,30, 5,16, 9, 8, 5,18, 9, 2, 7, 5,20,21;

1 , 2, 3, 4, 5,14,5 ,15, 5,16, 5,17, 5,18, 7, 8, 9, 2, 5, 6, 7;

8 , 1, 2, 4, 5,14, 5,15, 5,16, 5,17, 5,18, 2, 5,19, 5, 8,9 ,10;

14, 5,15, 5,16, 5,17, 5,18, 7, 8, 9, 2, 5, 6, 7, 5,13,17,21,19;

5 ,14, 9,10, 4, 5,15,16,21,22, 9, 3, 4, 5, 7, 8, 9,10, 5,30,20;

6 ,7 ,8 ,5 ,14, 9,10, 5,15, 5,16, 5, 8, 6, 7, 9, 7,10, 7, 4, 3;

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5 ,17, 5,18, 7, 8, 9, 2, 5, 6, 7, 5,13,17,21,19, 8, 1, 2, 4, 5;

5 ,15,16, 5,17, 5,18, 5,19, 5, 8, 9,10, 1, 2, 3, 4, 5, 0, 0, 0;

4 ,15,16,21,22, 9, 3, 4, 5, 7, 8, 9,10, 5,30,20, 5,13,17,21,19;

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8 , 1, 2, 4, 5,14, 5,15, 5,16, 5,17, 5,18, 2, 5,19, 5, 8, 9,10;

5 , 7, 8, 4, 3, 5,19, 5,30, 5,16, 9, 8, 5,30, 9, 8,10,16, 0, 0;

1 , 2, 3, 4, 5, 6, 7, 8, 5,14, 9,10, 5,15, 5,16, 5, 8, 6, 7, 9;

Table 1Codified web logs of a user

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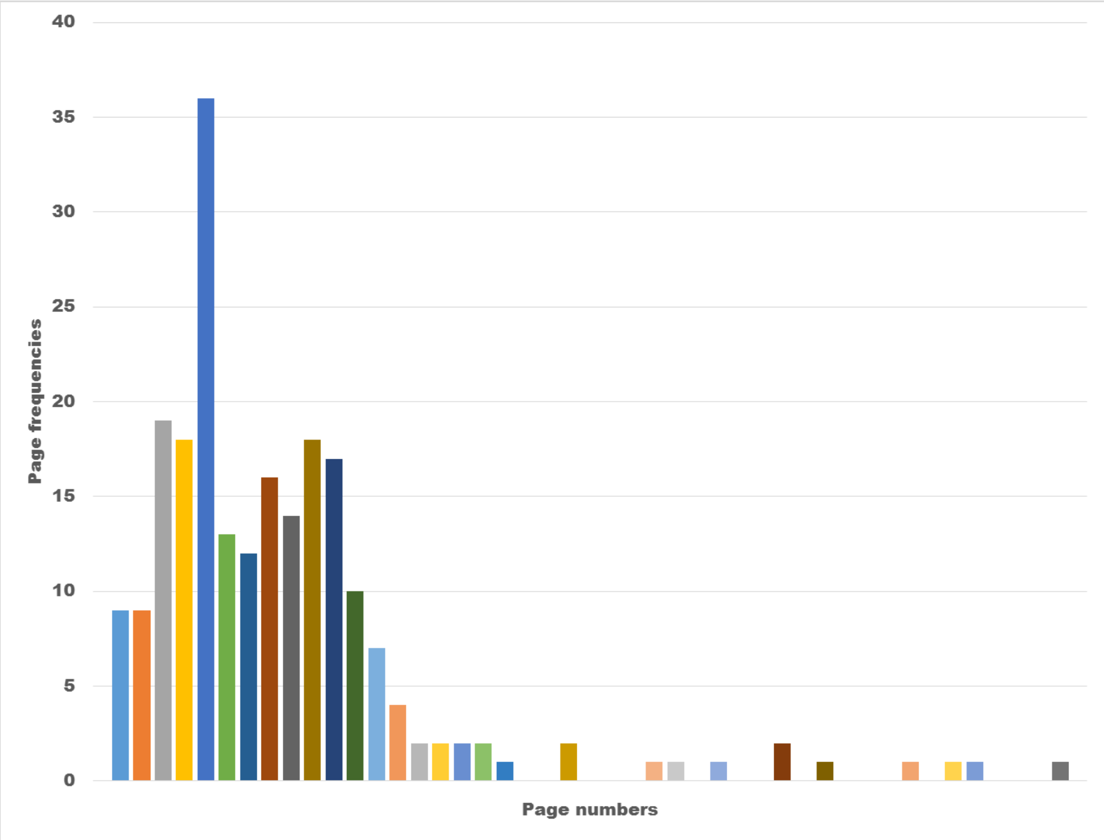

Fig.4 Pages visited by different number of users

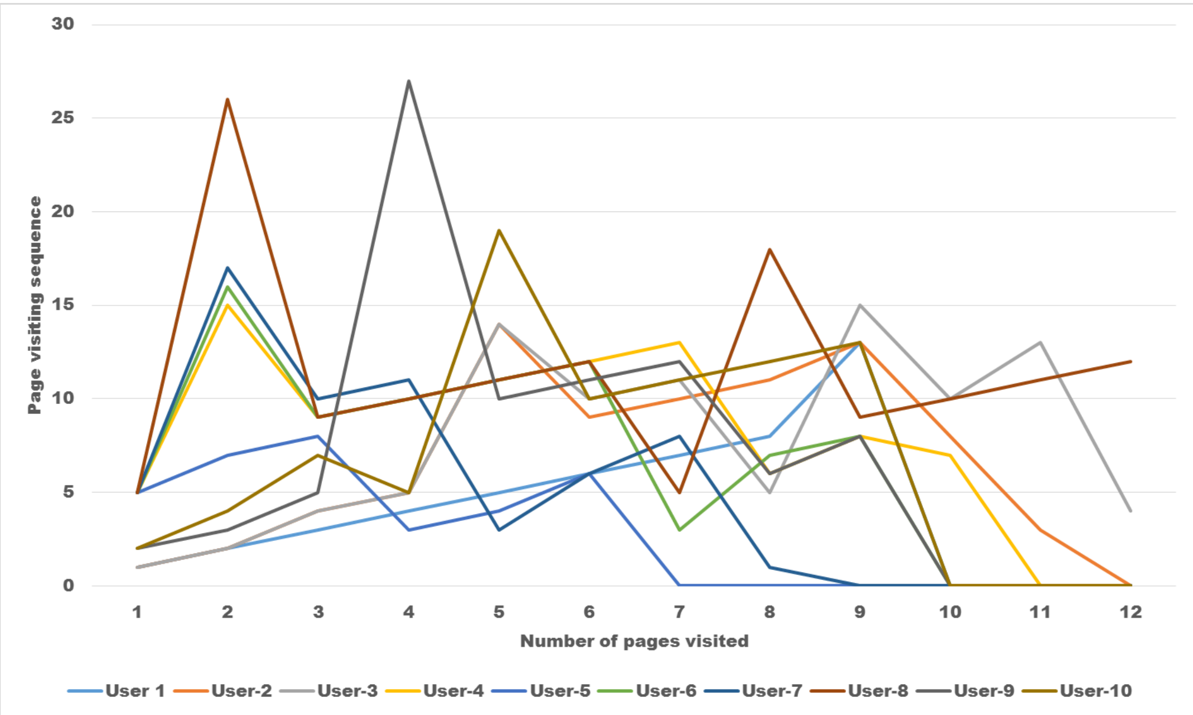

Fig.5 Page visiting sequence

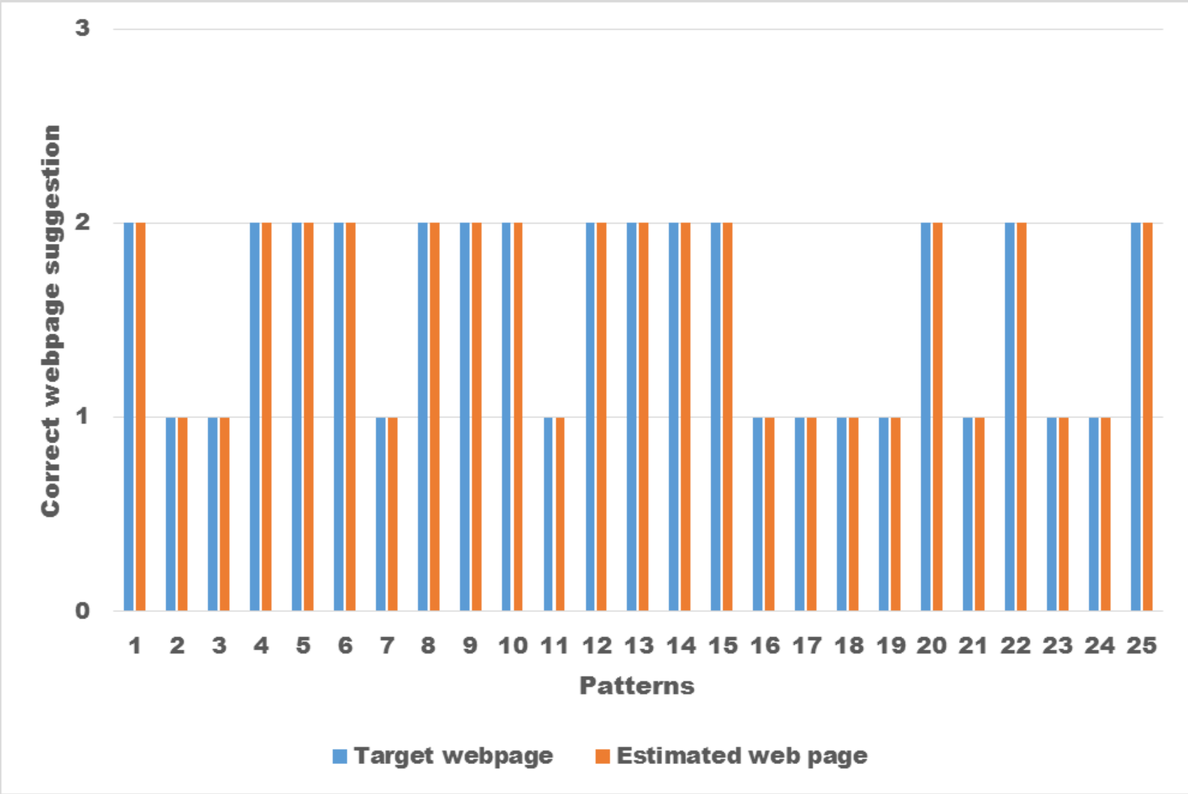

Fig.6 Fuzzy output

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LOW FREQUENCY OSCILLATIONS DAMPED BY USING D-FACTS CONTROLLER

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Abstract: **The paper demonstrates the basic module, steady state operation, mathematical analysis, and current injection modeling of the DPFC for two area. The purpose of the work reported in this paper is to design an oscillation damping controller for DPFC to damp low frequency electromechanical oscillations. The optimal design problem is formulated as an optimization problem, and particle swarm optimization (PSO) is employed to search for the damping controller parameters. Results demonstrate that DPFC with the proposed model can more effectively improve the dynamic stability and enhance the transient stability of power system compared to the genetic algorithm based damping controllers. The r and λ are relative magnitude and phase angle of DPFC controller. Moreover, the results show that the λ based controller is superior to the r based controller.**

Keywords: DFACTS, DPFC, UPFC, Power Flow Controller, current injection model.

I. INTRODUCTION

Presently, power demand is growing dramatically and the extension in transmission and generation is restricted with the rigid environmental constraints and limited availability of resources. As a result, power systems of today are far more loaded than before. This brings about the necessity for power systems to be operated near their stability limits. Moreover, interconnection between remotely located power systems gives rise to low-frequency oscillations in the range of 0.1-0.3 Hz. If not well damped, these oscillations may keep growing in magnitude, resulting in a loss of synchronism .Power system stabilizers (PSSs) have been used over the recent decades to serve the purpose of improving power system damping to low-frequency oscillations. PSSs have proven to be efficient in performing their assigned tasks, which operate on the excitation system of generators [1]. However, PSSs may unfavorably have an effect on the voltage profile, may result in a leading power factor, and may be unable to control oscillations caused by large disturbances.

The UPFC is the combination of a static synchronous compensator (STATCOM) and a static synchronous series compensator (SSSC), which are coupled via a common dc link, to allow bidirectional flow of active power between the series out-put terminals of the SSSC and the shunt output terminals of the STATCOM. The converter in series with the line provides the main function of the UPFC by injecting a four-quadrant voltage with controllable magnitude and phase. The injected voltage essentially acts as a synchronous ac-voltage source, which is used to vary the transmission angle and line impedance, there by independently controlling the

active and reactive power flow through the line. The series voltage results in active and reactive power injection or absorption between the series converter and the transmission line.

This reactive power is generated internally by the series converter (see e.g., SSSC), and the active power is supplied by the shunt converter that is back-to-back connected. The shunt converter controls the voltage of the dc capacitor by absorbing or generating active power from the bus; therefore, it acts as a synchronous source in parallel with the system. Similar to the STATCOM, the shunt converter can also provide reactive compensation for the bus.

II. DPFC PRINCIPLE

Two approaches are applied to the UPFC to increase the reliability and to reduce the cost; they are as follows. First, eliminating the common dc link of the UPFC and second distributing the series converter, as shown in Fig. 1. By combining these two approaches, the new FACTS device DPFC is achieved. The DPFC consists of one shunt and several series-connected converters. The shunt converter is similar as a STATCOM, while the series converter employs the D-FACTS concept, which is to use multiple single-phase converters instead of one large rated converter. Each converter within the DPFC is independent and has its own dc capacitor to provide the required dc voltage. As shown, besides the key components, namely the shunt and series converters, the DPFC also requires a high-pass filter that is shunt connected at the other side of the transmission line, and two Y–Δ transformers at each side of the line. The reason for these extra components will be explained later. The unique control capability of the UPFC is given by the back-to-back connection between the shunt and series converters, which allows the active power to exchange freely[1]. To ensure that the DPFC have the same control capability as the UPFC, a method that allows the exchange of active power between converters with eliminated dc link is the prerequisite.

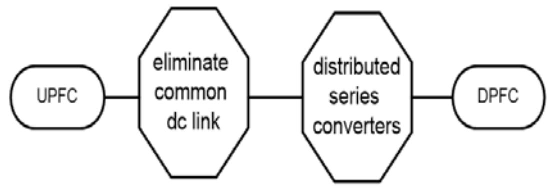

Fig.1.Power System of the case study equipped with DPFC

III. DPFC Topology

By introducing the two approaches outlined in the previous section (elimination of the common DC link and distribution of the series converter) into the UPFC, the DPFC is achieved. Similar as the UPFC, the DPFC consists of shunt and series connected converters. The shunt converter is similar as a STATCOM, while the series converter employs the DSSC concept, which is to use multiple single - phase converters instead of one three-phase converter[1]. Each converter within the DPFC is independent and has its own DC capacitor to provide the required DC voltage. The configuration of the DPFC is shown in Figure shown below As shown, besides the key components shunt and series converters, a DPFC also requires a high pass filter that is shunt connected to the other side of the transmission line and a Y-Δ transformer on each side of the line. The reason for these extra components will be explained later. The unique control capability of the UPFC is given by the back-to-back connection between the shunt and series

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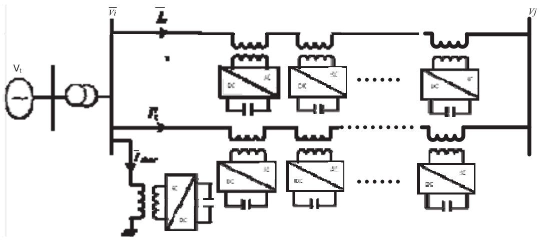

Fig.2. Power System of the case study equipped with DPFC.

converters, which allows the active power to freely exchange. To ensure the DPFC has the same control capability as the UPFC, a method that allows active power exchange between converters with an eliminated DC link is required.

Figure 3 shows Active power exchange with eliminated DC link With in the DPFC, the transmission line presents a common connection between the AC ports of the shunt and the series converters. Therefore, it is possible to exchange active power through the AC ports. The method is based on power theory of non-sinusoidal components. According to the Fourier analysis, non-sinusoidal voltage and current can be expressed as the sum of sinusoidal functions in different frequencies with different amplitudes [1]. The active power resulting from this non sinusoidal voltage and current is defined as them an value of the product of voltage and current. Since the integrals of all the cross product of terms with different frequencies are zero, the active power can be expressed by:

$$P = V_i I_i \cos\phi_i \qquad (a)$$

The independence of the active power at different frequencies gives the possibility that a converter without a power source can generate Neglecting losses, the active power generated at the fundamental frequency is equal to the power absorbed at the harmonic frequency.

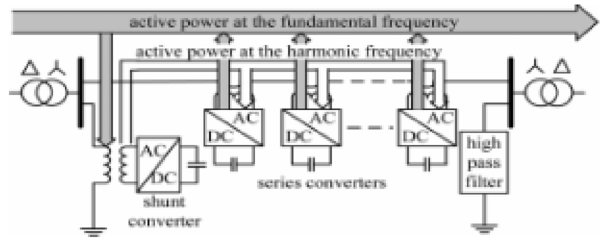

Fig.3. Active Power exchanger between converters.

Figure 2 indicates how the active power is exchanged between the shunt and the series converters in the DPFC system. The high pass filter with in the DPFC blocks the fundamental frequency components and allows the harmonic components to pass, thereby providing are turn path for the harmonic components. The shunt and series converters, the high pass filter and the ground form a closed loop for the harmonic current.

IV. Particle Swarm Optimization (PSO)Algorithm

Particle swarm optimization (PSO) is a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality .This algorithm was simplified and it was observed to be performing optimization. PSO gets better results in a faster, cheaper way compared with other methods. There are only few parameters to adjust. PSO does not use the gradient of the problem being optimized, which means PSO does not require that the optimization problem be differentiable.

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PSO makes few or no assumptions about the problem being optimized can search very large spaces of candidate solutions [4]. PSO also used on optimization problems that are partially irregular, noisy, change over time, etc.

This new approach features many advantages; it is simple, fast and easy to be coded. Also, its memory storage requirement is minimal. Moreover, this approach is advantageous over evolutionary and genetic algorithms in many ways.

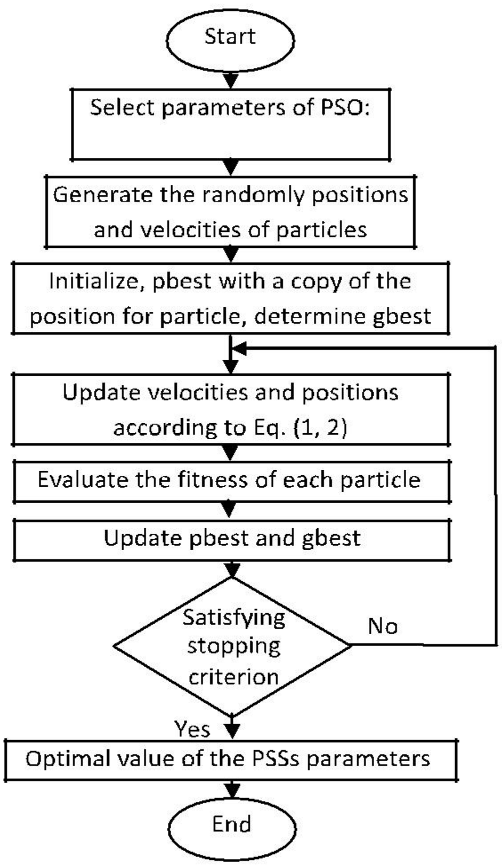

Fig.4. Flowchart of the PSO technique

V. DPFC CONTROL

To control multiple converters, a DPFC consists of three types of controllers: central control, shunt control and series control, as shown in fig.5.

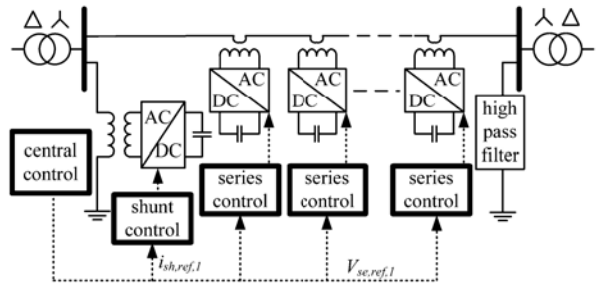

Fig.5. DPFC control block diagram.

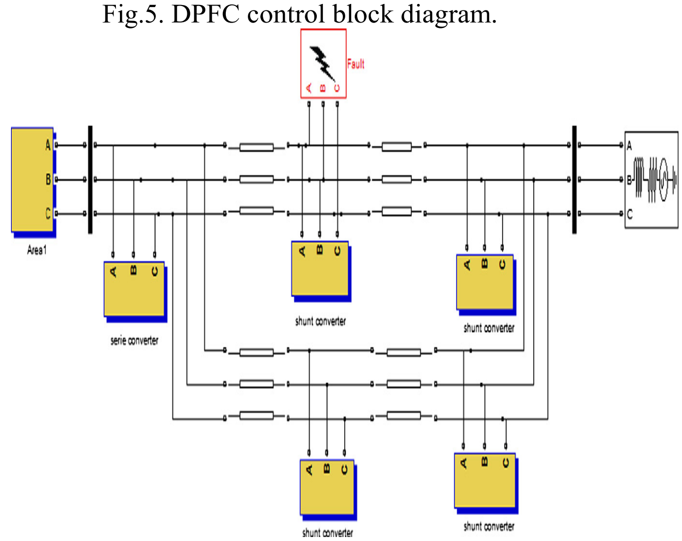

Fig.6.Existing system with single area built with MATLAB/Simulink.

VI. DESIGN OF DPFC CONTROLLER

The DPFC has three control variables. The current of sending and receiving end buses can be changed through controlling of DPFC parameters r, and Iq. In the case of power flow control, the DPFC regulates active and reactive power flow in transmission line at the specified values P_{ref} and Q_{ref}. in Fig.7 shows the control system of DPFC for power flow controlling. With notice to power system nonlinearity, designing controller parameters is difficult and it is done by try and error.

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In this paper for overcoming to this problem, the PSO algorithm is used and designing of controller parameters is converted to an optimization problem.

TABLE 1 OPTIMAL PARAMETERS OF THE CONTROLLERS.

Controller parameter	**PSO based λcontroller**	**PSO based rcontroller**	**GA based λcontroller**	**GA based r controller**
k	95.56	89.215	53	43.12
T1	0.1416	0.2314	0.101	0.4211
T2	0.4713	0.5142	2.112	3.1254
T3	1	0.7514	0.5297	0.7456
T4	0.0716	0.0914	1.4348	1.0541

VII. Design of DPFC damping controller using PSO technique:

It is worth mentioning that the designed controller with proposed model is tuned to damp power system oscillations with minimum control effort following a disturbance [17]. An Integral of Time multiplied Absolute value of the Error is considered as the fitness function, in this study.

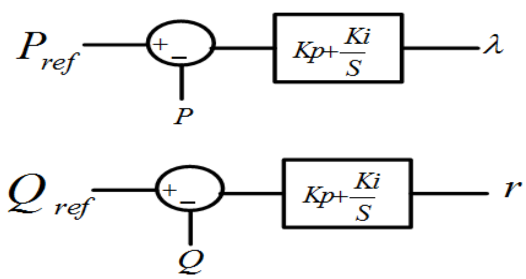

Fig.7. DPFC damping controller

The objective function defined as follows:

$$J=\int_0^{tsim} t(\Delta Wi) \quad (1)$$

$$F=\sum_{i=1}^{Np} Ji$$

In Equations (1) and (2), $t_{sim}$is the time range of simulation, and Np is the total number of operating points for which the optimization is carried out.

$$\begin{gathered} k^{min}\leq k\leq k^{max} \\ {T_1}^{min}\leq T_1 \leq {T_1}^{max} \\ {T_2}^{min}\leq T_2\leq {T_2}^{max} \\ {T_3}^{min}\leq T_3\leq {T_3}^{max} \\ {T_4}^{min}\leq T_4\leq {T_4}^{max} \end{gathered} \quad (2)$$

7.1. Non-linear time-domain simulation:

The proposed control scheme for DPFC is evaluated by computer simulation in MATLAB/Simulink. The details of simulation model are depicted in Fig. 8. The parameters of test power system are listed and the machine parameters including nominal voltage and power, impedance and phase angle of sending and receiving ends are presented in Table 1.

In order to assess the robustness of the designed damping controller, simulation studies are carried out for three scenarios occurred as demonstrated below.

7.1.1 Scenario 1

In this scenario, it is considered a 6-cycle three-phase fault occurred at t = 1 s at the middle of the one transmission line cleared by permanent tripping of the faulted line. The speed deviation of generator at nominal, light, and heavy loading conditions due to designed controller for k and r by PSO algorithm are shown in Fig. 4. Also, 8 shows the generator output power, internal voltage variations, and excitation volt-age deviation with k and r based controllers for nominal loading conditions, respectively. These figures obviously show the good damping effect of the supplementary controller.

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7.1.2. Scenario 2

A 6-cycle three-phase fault occurred at t= 1 s at the middle of one of the transmission line is considered. The fault is cleared without line tripping, and the original system is restored upon the clearance of the fault. The system response to this disturbance is shown in Fig.9. It can be seen that the proposed model based optimized DPFC damping controller has good performance in damping low frequency oscillations and stabilizes the system quickly. From the above conducted tests, it can be concluded that the k based damping controller is superior to the r based damping controller tuned by PSO algorithm.

7.1.3. Scenario 3

A 6-cycle signal-phase fault occurred at t =1 s at the middle of one of the transmission line is considered. The fault is cleared without line tripping, and the original system is restored upon the clearance of the fault. The speed deviation of generator at base nominal loading condition with control parameters of the k and r is shown in Figs. 9 and 10, respectively.

The performance of the PSO based damping controller is quite prominent in comparison with the GA based damping controller, and the overshoots and settling time are significantly improved for the proposed controller. It can be seen that the system response with the PSO based damping controller settles faster and provides superior damping. To demonstrate performance robustness of the proposed method, two performance indices: ITAE and FD based on the system performance characteristics are defined as:

$$\text{ITAE}=1000\int_0^{t_{sim}} t(\Delta w)dt \qquad (3)$$

$$\text{FD}=(1000 \times OS)^2+(3000 \times US)^2+T^2 \qquad (4)$$

Where, speed deviation (Δ_w), Overshoot (OS), Undershoot (US), and settling time of speed deviation of the machine are considered for evaluation of the ITAE and FD indices. It is worth mentioning that the lower the value of these indices is, the better the system response in terms of time-domain characteristics.

Numerical results of performance robustness for all system loading cases are listed in Table 2. This demonstrates that the overshoot, undershoot, settling time, and speed deviations of the machine are greatly reduced by applying the proposed PSO based tuned controller [1].

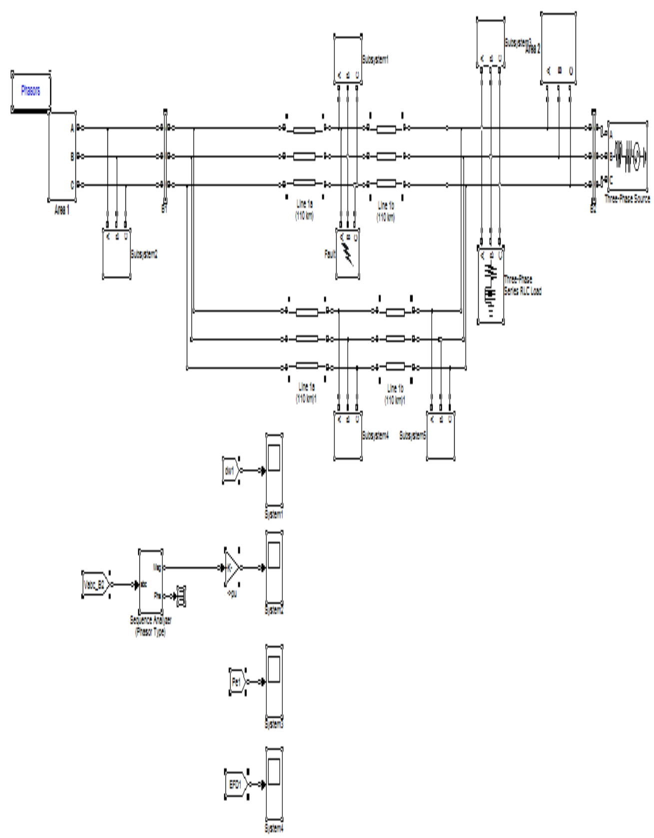

Figure.8. SMIB with 2-area DPFC built with MATLAB/Simulink

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Table 2 Parameters of test power system.

Parameter	E_s (KV)	E_r (KV)	F (Hz)	S (MVA)	Deg	Deg	Linelength (km)
Value	230	230	60	900	10	0	220

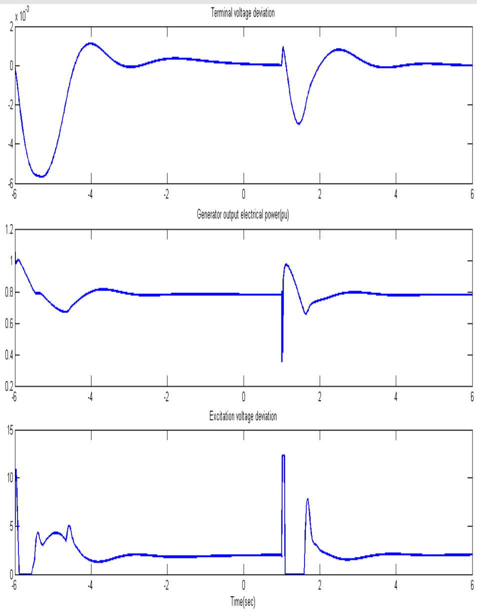

FIG 9.DPFC with Single area: Dynamic responses at nominal loading: (a) terminal voltage deviation, (b) output electrical power (pu), (c)excitation voltage.

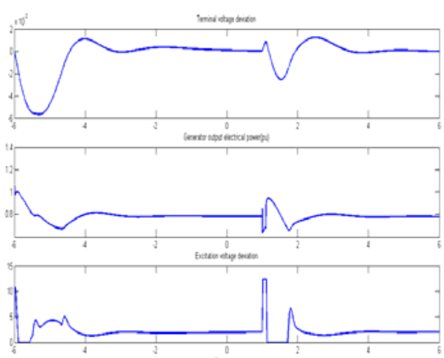

Fig.10.DPFC with two area: Dynamic responses at nominal loading : (a) terminal voltage deviation, (b) output electrical power (pu), (c) excitation voltage for different parameters.

CONCLUSION

In this study, the DPFC as new FACTS device that to can regulate line active and reactive power flow of the transmission line and provide enough damping to system oscillation modes. The initiatives of the presented work are given as follows:

- The mathematical analysis and current injection modeling of a new FACTS device based on distributed power flow controller are presented.
- A novel current injection model of the DPFC for studying on the low frequency oscillations is proposed for the first time.
- The proposed model of the DPFC is explained with 2-area, and it can be implemented in MATLAB/SIMULINK environment and further can be extended for different applications in example power system.
- The design problem of the DPFC damping controller parameters is converted into an optimization problem which is solved by a PSO technique that has a strong ability to find the most optimistic results.

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International Journal of Computer Science and Information Security

IJCSIS 2014
ISSN: 1947-5500
http://sites.google.com/site/ijcsis/

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Authors are solicited to contribute to the special issue by submitting articles that illustrate research results, projects, surveying works and industrial experiences that describe significant advances in the following areas, but are not limited to. Submissions may span a broad range of topics, e.g.:

Track A: Security

Access control, Anonymity, Audit and audit reduction & Authentication and authorization, Applied cryptography, Cryptanalysis, Digital Signatures, Biometric security, Boundary control devices, Certification and accreditation, Cross-layer design for security, Security & Network Management, Data and system integrity, Database security, Defensive information warfare, Denial of service protection, Intrusion Detection, Anti-malware, Distributed systems security, Electronic commerce, E-mail security, Spam, Phishing, E-mail fraud, Virus, worms, Trojan Protection, Grid security, Information hiding and watermarking & Information survivability, Insider threat protection, Integrity
Intellectual property protection, Internet/Intranet Security, Key management and key recovery, Language-based security, Mobile and wireless security, Mobile, Ad Hoc and Sensor Network Security, Monitoring and surveillance, Multimedia security ,Operating system security, Peer-to-peer security, Performance Evaluations of Protocols & Security Application, Privacy and data protection, Product evaluation criteria and compliance, Risk evaluation and security certification, Risk/vulnerability assessment, Security & Network Management, Security Models & protocols, Security threats & countermeasures (DDoS, MiM, Session Hijacking, Replay attack etc,), Trusted computing, Ubiquitous Computing Security, Virtualization security, VoIP security, Web 2.0 security, Submission Procedures, Active Defense Systems, Adaptive Defense Systems, Benchmark, Analysis and Evaluation of Security Systems, Distributed Access Control and Trust Management, Distributed Attack Systems and Mechanisms, Distributed Intrusion Detection/Prevention Systems, Denial-of-Service Attacks and Countermeasures, High Performance Security Systems, Identity Management and Authentication, Implementation, Deployment and Management of Security Systems, Intelligent Defense Systems, Internet and Network Forensics, Large-scale Attacks and Defense, RFID Security and Privacy, Security Architectures in Distributed Network Systems, Security for Critical Infrastructures, Security for P2P systems and Grid Systems, Security in E-Commerce, Security and Privacy in Wireless Networks, Secure Mobile Agents and Mobile Code, Security Protocols, Security Simulation and Tools, Security Theory and Tools, Standards and Assurance Methods, Trusted Computing, Viruses, Worms, and Other Malicious Code, World Wide Web Security, Novel and emerging secure architecture, Study of attack strategies, attack modeling, Case studies and analysis of actual attacks, Continuity of Operations during an attack, Key management, Trust management, Intrusion detection techniques, Intrusion response, alarm management, and correlation analysis, Study of tradeoffs between security and system performance, Intrusion tolerance systems, Secure protocols, Security in wireless networks (e.g. mesh networks, sensor networks, etc.), Cryptography and Secure Communications, Computer Forensics, Recovery and Healing, Security Visualization, Formal Methods in Security, Principles for Designing a Secure Computing System, Autonomic Security, Internet Security, Security in Health Care Systems, Security Solutions Using Reconfigurable Computing, Adaptive and Intelligent Defense Systems, Authentication and Access control, Denial of service attacks and countermeasures, Identity, Route and

Location Anonymity schemes, Intrusion detection and prevention techniques, Cryptography, encryption algorithms and Key management schemes, Secure routing schemes, Secure neighbor discovery and localization, Trust establishment and maintenance, Confidentiality and data integrity, Security architectures, deployments and solutions, Emerging threats to cloud-based services, Security model for new services, Cloud-aware web service security, Information hiding in Cloud Computing, Securing distributed data storage in cloud, Security, privacy and trust in mobile computing systems and applications, **Middleware security & Security features:** middleware software is an asset on its own and has to be protected, interaction between security-specific and other middleware features, e.g., context-awareness, **Middleware-level security monitoring and measurement:** metrics and mechanisms for quantification and evaluation of security enforced by the middleware, **Security co-design:** trade-off and co-design between application-based and middleware-based security, **Policy-based management:** innovative support for policy-based definition and enforcement of security concerns, **Identification and authentication mechanisms:** Means to capture application specific constraints in defining and enforcing access control rules, **Middleware-oriented security patterns:** identification of patterns for sound, reusable security, **Security in aspect-based middleware:** mechanisms for isolating and enforcing security aspects, **Security in agent-based platforms:** protection for mobile code and platforms, Smart Devices: Biometrics, National ID cards, Embedded Systems Security and TPMs, RFID Systems Security, Smart Card Security, Pervasive Systems: Digital Rights Management (DRM) in pervasive environments, Intrusion Detection and Information Filtering, Localization Systems Security (Tracking of People and Goods), Mobile Commerce Security, Privacy Enhancing Technologies, Security Protocols (for Identification and Authentication, Confidentiality and Privacy, and Integrity), Ubiquitous Networks: Ad Hoc Networks Security, Delay-Tolerant Network Security, Domestic Network Security, Peer-to-Peer Networks Security, Security Issues in Mobile and Ubiquitous Networks, Security of GSM/GPRS/UMTS Systems, Sensor Networks Security, Vehicular Network Security, Wireless Communication Security: Bluetooth, NFC, WiFi, WiMAX, WiMedia, others

This Track will emphasize the design, implementation, management and applications of computer communications, networks and services. Topics of mostly theoretical nature are also welcome, provided there is clear practical potential in applying the results of such work.

Track B: Computer Science

Broadband wireless technologies: LTE, WiMAX, WiRAN, HSDPA, HSUPA, Resource allocation and interference management, Quality of service and scheduling methods, Capacity planning and dimensioning, Cross-layer design and Physical layer based issue, Interworking architecture and interoperability, Relay assisted and cooperative communications, Location and provisioning and mobility management, Call admission and flow/congestion control, Performance optimization, Channel capacity modeling and analysis, Middleware Issues: Event-based, publish/subscribe, and message-oriented middleware, Reconfigurable, adaptable, and reflective middleware approaches, Middleware solutions for reliability, fault tolerance, and quality-of-service, Scalability of middleware, Context-aware middleware, Autonomic and self-managing middleware, Evaluation techniques for middleware solutions, Formal methods and tools for designing, verifying, and evaluating, middleware, Software engineering techniques for middleware, Service oriented middleware, Agent-based middleware, Security middleware, Network Applications: Network-based automation, Cloud applications, Ubiquitous and pervasive applications, Collaborative applications, RFID and sensor network applications, Mobile applications, Smart home applications, Infrastructure monitoring and control applications, Remote health monitoring, GPS and location-based applications, Networked vehicles applications, Alert applications, Embeded Computer System, Advanced Control Systems, and Intelligent Control : Advanced control and measurement, computer and microprocessor-based control, signal processing, estimation and identification techniques, application specific IC's, nonlinear and adaptive control, optimal and robot control, intelligent control, evolutionary computing, and intelligent systems, instrumentation subject to critical conditions, automotive, marine and aero-space control and all other control applications, Intelligent Control System, Wiring/Wireless Sensor, Signal Control System. Sensors, Actuators and Systems Integration : Intelligent sensors and actuators, multisensor fusion, sensor array and multi-channel processing, micro/nano technology, microsensors and microactuators, instrumentation electronics, MEMS and system integration, wireless sensor, Network Sensor, Hybrid

Sensor, Distributed Sensor Networks. Signal and Image Processing : Digital signal processing theory, methods, DSP implementation, speech processing, image and multidimensional signal processing, Image analysis and processing, Image and Multimedia applications, Real-time multimedia signal processing, Computer vision, Emerging signal processing areas, Remote Sensing, Signal processing in education. Industrial Informatics: Industrial applications of neural networks, fuzzy algorithms, Neuro-Fuzzy application, bioInformatics, real-time computer control, real-time information systems, human-machine interfaces, CAD/CAM/CAT/CIM, virtual reality, industrial communications, flexible manufacturing systems, industrial automated process, Data Storage Management, Harddisk control, Supply Chain Management, Logistics applications, Power plant automation, Drives automation. Information Technology, Management of Information System : Management information systems, Information Management, Nursing information management, Information System, Information Technology and their application, Data retrieval, Data Base Management, Decision analysis methods, Information processing, Operations research, E-Business, E-Commerce, E-Government, Computer Business, Security and risk management, Medical imaging, Biotechnology, Bio-Medicine, Computer-based information systems in health care, Changing Access to Patient Information, Healthcare Management Information Technology. Communication/Computer Network, Transportation Application : On-board diagnostics, Active safety systems, Communication systems, Wireless technology, Communication application, Navigation and Guidance, Vision-based applications, Speech interface, Sensor fusion, Networking theory and technologies, Transportation information, Autonomous vehicle, Vehicle application of affective computing, Advance Computing technology and their application : Broadband and intelligent networks, Data Mining, Data fusion, Computational intelligence, Information and data security, Information indexing and retrieval, Information processing, Information systems and applications, Internet applications and performances, Knowledge based systems, Knowledge management, Software Engineering, Decision making, Mobile networks and services, Network management and services, Neural Network, Fuzzy logics, Neuro-Fuzzy, Expert approaches, Innovation Technology and Management : Innovation and product development, Emerging advances in business and its applications, Creativity in Internet management and retailing, B2B and B2C management, Electronic transceiver device for Retail Marketing Industries, Facilities planning and management, Innovative pervasive computing applications, Programming paradigms for pervasive systems, Software evolution and maintenance in pervasive systems, Middleware services and agent technologies, Adaptive, autonomic and context-aware computing, Mobile/Wireless computing systems and services in pervasive computing, Energy-efficient and green pervasive computing, Communication architectures for pervasive computing, Ad hoc networks for pervasive communications, Pervasive opportunistic communications and applications, Enabling technologies for pervasive systems (e.g., wireless BAN, PAN), Positioning and tracking technologies, Sensors and RFID in pervasive systems, Multimodal sensing and context for pervasive applications, Pervasive sensing, perception and semantic interpretation, Smart devices and intelligent environments, Trust, security and privacy issues in pervasive systems, User interfaces and interaction models, Virtual immersive communications, Wearable computers, Standards and interfaces for pervasive computing environments, Social and economic models for pervasive systems, Active and Programmable Networks, Ad Hoc & Sensor Network, Congestion and/or Flow Control, Content Distribution, Grid Networking, High-speed Network Architectures, Internet Services and Applications, Optical Networks, Mobile and Wireless Networks, Network Modeling and Simulation, Multicast, Multimedia Communications, Network Control and Management, Network Protocols, Network Performance, Network Measurement, Peer to Peer and Overlay Networks, Quality of Service and Quality of Experience, Ubiquitous Networks, Crosscutting Themes – Internet Technologies, Infrastructure, Services and Applications; Open Source Tools, Open Models and Architectures; Security, Privacy and Trust; Navigation Systems, Location Based Services; Social Networks and Online Communities; ICT Convergence, Digital Economy and Digital Divide, Neural Networks, Pattern Recognition, Computer Vision, Advanced Computing Architectures and New Programming Models, Visualization and Virtual Reality as Applied to Computational Science, Computer Architecture and Embedded Systems, Technology in Education, Theoretical Computer Science, Computing Ethics, Computing Practices & Applications

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ISSN 1947 5500
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